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a pilot study: health hazard of fume exposure and associated occupations

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A PILOT STUDY:
HEALTH HAZARD OF FUME EXPOSURE AND ASSOCIATED OCCUPATIONS

Environmental Health Directorate
Health Protection Branch

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HATCH ASSOCIATES LTD.

Roger Dixon, P. Eng., M.P.H., C.I.H.,
Consultant, Occupational Health and Safety,

Linda Michaels, B.A., D.I.H.,
Research Assistant.

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1. INTRODUCTION

This document presents the findings of a pilot study covering the occupational health status of welders (including brazers, flame cutters and metal sprayers) in Canada. The planning of the study has been, as far as possible, in accordance with the subject matter groupings contained in the Agreement. The requirements contained in the Agreement were as follows:

"To review the available information on welding (The term "welding" shall be taken to include brazing, flame cutting of metals, metal spraying or any other activity which an employee designated as a "welder" is normally likely to engage in.) in Canada. This review will cover 13 jurisdictions:

(a) The 10 Provinces;
(b) The Canada Labour Code;
(c) The Department of National Defence; and
(d) The Medical Services Branch of the Department of National Health and Welfare.

The study shall include the following elements:

(a) Identify and describe the various welding processes;
(b) Document the materials used, thermal sources and composition of emissions to which the welder is exposed;
(c) Estimate the number of persons employed at each type of process;
(d) Identify and describe occupational health programs in operation within each jurisdiction, as these relate to welding hazard;
(e) Describe data record systems relating to worker exposure (environmental and biological monitoring programs), and employment medical supervision, relating to workers at risk in welding;
(f) Review the utility of data record systems for future epidemiological studies and other research objectives relating to welding health risk; and
(g) Identify and describe welding hazard situations as perceived by the welder."

A comprehensive review of processes and materials is made in Section 3.1. The occupational health hazards associated with these are dealt with in Section 3.2 under the separate heading; "Health Hazards; Welder's Exposure to Fume". In both these Sections, the link between processes, materials and hazards is clearly made.

Recognizing that this document serves as an introduction to occupational health factors prevailing in the working environment of the Canadian welder, Section 3.1, dealing specifically with processes, techniques, methodologies and materials, provides an essential background for an understanding of where hazardous or potentially hazardous situations may occur.

In Section 3.2, the discussion on welding materials and their hazard characteristics is preceded by an outline; "Factors in Risk Evaluation", Table 4, and a list; "Hazardous Materials in Welding", Table 5. Figure 5 illustrates one method of classifying the principal gases and particulate found in welding fume.

The Section proceeds to document the occurrence and toxicology of inhaled particulate matter (dust and metal fume), and toxic gases.

N.B.

Throughout the report, the terms "fume", or "welding fume", are used to denote all materials, particulate and gaseous, present in the worker's breathing zone as a result of welding, brazing, flame cutting and metal spraying. This is in recognition of common usage in the workplace. To be technically correct, the term "fume" would apply only to airborne particulate matter generally less than 1 micron in diameter produced by the vaporization and rapid atmospheric oxidation of a metal.

Similarly, the term "welding" is used collectively to encompass welding, brazing, flame cutting, metal spraying and attendant operations such as soldering, since much of the subject matter under discussion is common to all operations. Where the collective use of "welding" is not appropriate, the distinction is accordingly made.

Section 3.3, "Sources for Estimation of Population at Risk", records the outcome of a series of direct approaches made to employers, labour organizations, government authorities and trade/professional organizations. The number of persons at risk in welding and associated operations has proved to be an elusive figure, due to lack of objectivity and organization in record keeping. This casual approach in defining welders, and to maintaining records of their employment and whereabouts was evident in nearly all the organizations contacted. The Province of Alberta, and the Canadian Welding Bureau appeared to have the most ready access to facts and figures, but these alone are of little contribution to a national survey because of partial duplication of these figures by other authorities. Omissions, duplication of records, indeterminate trade and occupational classifications, and the transient nature of some welding operations, are all obstacles to establishing the size of the Canadian welding population. A best estimate of Boiler and Pressure Vessel Certified welders is presented in Table 7, while Table 8 gives a summary of total welding population estimates from other sources.

Section 4 documents in detail the Regulations attendant upon welding and associated activities in 13 jurisdictions. These regulations are prolific, and their implementation is undoubtedly impeded by inter-departmental duplication or research, enforcement and inspectional responsibility.

Section 5 introduces a number of considerations in epidemiological findings and occupational exposure/medical records. One of the objectives here is to document the existence of data resources in Canada which could be used in support of further studies of risk factors and morbidity/mortality in the welding environment. In general, there does not exist at the present time a coordinated array of data which could be applied directly to studies of causal relationships in welders' occupational health. A number of potential channels for the extraction of suitably refined data are discussed.

In our communications with labour organizations at the national and local levels, Section 6, we see growing concern with the perceived inadequacies of occupational health law. There is widespread pressure for more clearly defined workplace hazard control standards, and for more effective enforcement of existing regulations. Up until now, welding and related activities appear to have taken second place to such contemporary issues as asbestosis, silicosis, noise and lead exposure.

There are clear signs, however, that indications of the presence of carcinogens in welding fume (nickel, chromium, cobalt alloys and some filler materials) will induce labour to make some very stringent demands for hazard identification, and for the enforcement of adequate hazard control or elimination measures in the welding workplace.

Selected industrial hygiene topics are discussed in Section 7. A broad ranging discussion is outside the scope of this report, but an attempt is made to introduce some relevant issues, and to document areas of principal concern with respect to the organization of procedures for adequate hazard identification and control programs.

2. SUMMARY

Over the last decade, a variety of occupationally related diseases have been identified, many only in time to lend themselves to supportive medical treatment because of the irreversible nature of physiological changes produced in those affected. The information evaluated in the course of this pilot survey of welders leaves us with a definite measure of concern about the acute, subacute, and chronic effects of exposure to welding fume.

Having reviewed a selection of studies carried out on the effects of exposure to welding fume, we find both evidence for concern and for no increased risk. This apparent discrepancy may arise for research methodology reasons, including bias in sample selection, inadequate control of interfering and confounding variables in study and control groups, non-allowance for disease latency periods, and the lack of definition of causal agents (fume components).

This preliminary survey of authorities in government and the private and labour sectors, who are likely to be concerned with the health effects of welding fume, has identified few data records of sufficient scope and specificity to provide a reliable base for studies of the association between exposure and morbidity/ mortality. A closer inspection in selected areas is recommended, in particular the Computerized Record Linkage procedures discussed in Section 5.

It is possible to be overwhelmed with legislative detail when reviewing Canadian statutory provisions for the protection of workers' health. Nevertheless, we have attempted to document all those provisions in the federal and provincial areas of jurisdiction. Most of the regulations we have identified addressing the respiratory health risk of welders, however, do so within the framework of general workplace health standards. Where welder's occupational health risk is covered specifically, we find that the emphasis tends to be on safety and physical hazards.

In many jurisdictions, the establishment of workplace health and safety committees has resulted in an increasing awareness of the potentially hazardous nature of welding fume. This awareness is undoubtedly due, in part, to recent findings regarding potential carcinogens found in some fume. The suspected role of ubiquitous iron oxide fume in the etiology of malignant tumours is a source of great concern to union health and safety authorities, and to professional industrial hygienists in government and industry.

As so frequently happens in the promulgation of occupational health regulations, the intent is unimpeachable, but the instruments of enablement are lacking. There is a great need in Canada for some fundamental down-to-earth national guidelines for hazard identification, evaluation and control. Without these guidelines, worker protection cannot be satisfactorily achieved; without these guidelines, the law cannot be translated into meaningful action since there are no criteria against which to evaluate either risk itself, or risk control methods.

Proposals for specific performance standards for local exhaust ventilation equipment have been tendered by some authorities, including the Canadian Welding Bureau (Canadian Standards Association). Pending further study of the cost-effectiveness of such performance standards, we are attracted to the idea, as equally we are attracted to the idea of developing hazard evaluation procedures through fume characterization of welding consumables.

This pilot study of the various factors bearing upon the occupational health environment of the welder identifies areas of information shortage. In this connection we recommend that Canadian employment, insurance and workers compensation records and related data systems, be reviewed in order to identify areas where a more refined methodology could be introduced. The objective would be to guarantee accurate records on workplace exposure and medical surveillance as a workable data resource for future occupational health studies in general.

It would be timely for Canadian authorities to put in hand a thorough review of currently available medical evidence regarding the acute and chronic effects of exposure to welding fume, with specific attention given to suspected carcinogens. Consideration should then be given to running a retrospective cohort-continuation study of welders employed in areas of readily definable exposure.

3. WELDING PROCESSES, HEALTH HAZARDS AND POPULATION AT RISK

3.1 Processes and Materials

There are many processes listed under the heading of welding, brazing, cutting and metal spraying. This review is confined to a discussion of the principles and application of those procedures in common use in Canadian industry today. The material is presented in such a manner that the reader not familiar with these procedures can see where potentially hazardous exposure can occur as a result of the materials and work practices involved. The health effects associated with occupational exposures are discussed in Section 3.2.

3.1.1 Welding

Welding may be defined as the making of a union between pieces of metal or thermoplastic at joint faces rendered plastic or liquid by heat or pressure, or both.

The most common methods of welding are Gas Welding, Arc Welding, Inert Gas Arc Welding, and Resistance Welding.

3.1.1.1 Gas Welding

The source of heat for this type of welding is a gas flame produced by burning a hydrocarbon or hydrogen fuel gas in the presence of atmospheric oxygen alone or mixed with pure oxygen. Commercial oxygas flames use oxygen-acetylene, oxygen-hydrogen, and oxygen-natural gas mixtures. An alternative terminology for gas welding is Oxyfuel Gas Welding, or OFW.

The equipment used in oxyfuel gas welding is relatively low in cost, usually portable and applicable to a number of related operations, such as bending and straightening, pre-heating, braze welding and torch welding. Oxyacetylene welding is used widely in maintenance and repair work due to the portability and flexibility of the apparatus used. Welds may be made by using a welding rod (filler rod) of the same material as the base material or by using the base metal itself as the filler metal.

The following are the criteria for a fuel gas suitable for welding:

High flame temperature,
High rate of flame propagation,

Adequate heat content,

Minimum chemical reactivity of the flame with base (work-piece) and filler metal.

The characteristics of common fuel gases are presented in Table 1. The total heat of combustion arises from both the primary flame, where oxygen is supplied by the torch, and the secondary flame where combustion of the primary reaction products is supported by atmospheric oxygen. Table 2 shows the overall chemical reactions for the complete combustion of commonly-used fuel gases.

As an example of primary and secondary combustion, the reaction of acetylene can be presented in two stages:

Primary reaction, $C_2H_2 + O_2 \rightarrow 2CO + H_2$

Secondary reaction, $4CO + 2H_2 + 3O_2 \rightarrow 4CO_2 + 2H_2O$

Where stoichiometric balance is obtained by appropriately setting the oxygen and acetylene gas valves on the torch, the resultant flame is neutral, because there is no excess carbon or oxygen to carbonize or oxidize the metal. Excess fuel gas will produce a carbonizing flame, whilst excess oxygen will produce an oxidizing flame. An oxidizing flame is undesirable in the welding of many metals. One reason for using flux is to remove the oxides generated during welding, by producing fusible slags that will float to the top of the molten puddle so as not to interfere with the deposition of filler metal.

At the temperatures obtainable (up to 3500°C) with the gas welding torch, many ferrous and non-ferrous metals can be welded successfully. Ferrous metals amenable to the gas-welding procedure are cast iron, low carbon alloy steels (mild steels) and stainless steels containing chromium or chromium-nickel inclusions. Table 3 describes the general conditions for oxyacetylene welding of various ferrous metals. Non-ferrous metals which can be joined by the gas-welding technique include aluminum and aluminum alloys with small inclusions of manganese and magnesium, white metal (high zinc, high aluminum or high magnesium content with copper, tin, antimony or lead inclusions), copper, brass (copper and zinc), bronze (copper and tin), cupro-nickel alloys and lead.

TABLE 1

CHARACTERISTICS OF THE COMMON FUEL GASES

Fuel gas	Formula	Specific gravity 15.6°C (60°F) Air = 1	Volume to weight ratio (15.6°C)		Oxygen-to-fuel gas combustion ratio[a]	Flame temperature for oxygen[b]		Heat of combustion					
								Primary		Secondary		Total	
			m^3/kg	ft^3/lb		°C	°F	MJ/m^3	Btu/ft^3	MJ/m^3	Btu/ft^3	MJ/m^3	Btu/ft^3
Acetylene	C_2H_2	0.906	0.91	14.6	2.5	3087	5589	19	507	36	963	55	1470
Propane	C_3H_8	1.52	0.54	8.7	5.0	2526	4579	10	255	94	2243	104	2498
Methylacetylene-propadiene (MPS)[c]	C_3H_4	1.48	0.55	8.9	4.0	2927	5301	21	571	70	1889	91	2460
Propylene	C_3H_6	1.48	0.55	8.9	4.5	2900	5250	16	438	73	1962	89	2400
Natural gas (methane)	CH_4	0.62	1.44	23.6	2.0	2538	4600	0.4	11	37	989	37	1000
Hydrogen	H_2	0.07	11.77	188.7	0.5		4820					12	325

a. The volume units of oxygen required to completely burn a unit volume of fuel gas according to the formulae shown in Table 2. A portion of the oxygen is obtained from the atmosphere.

b. The temperature of the neutral flame.

c. May contain significant amounts of saturated hydrocarbons.

Adapted from: Welding Handbook, Vol. 2
American Welding Society

TABLE 2

CHEMICAL EQUATIONS FOR THE COMPLETE COMBUSTION OF THE COMMON FUEL GASES

Fuel Gas	Reaction with Oxygen
Acetylene	$C_2H_2 + 2.5O_2 \longrightarrow 2CO_2 + H_2O$
Methylacetylene-propadiene (MPS)	$C_3H_4 + 4O_2 \longrightarrow 3CO_2 + 2H_2O$
Propylene	$C_3H_6 + 4.5O_2 \longrightarrow 3CO_2 + 3H_2O$
Propane	$C_3H_8 + 5O_2 \longrightarrow 3CO_2 + 4H_2O$
Natural gas (methane)	$CH_4 + 2O_2 \longrightarrow CO_2 + 2H_2O$
Hydrogen	$H_2 + 0.5O_2 \longrightarrow H_2O$

TABLE 3

GENERAL CONDITIONS FOR OXYACETYLENE WELDING OF VARIOUS FERROUS METALS

Metal	Flame Adjustment	Flux	Welding Rod
Steel, cast	Neutral	No	Steel
Steel, pipe	Neutral	No	Steel
Steel plate	Neutral	No	Steel
Steel sheet	Neutral	No	Steel
	Slightly oxidizing	Yes	Bronze
High carbon steel	Reducing	No	Steel
Wrought iron	Neutral	No	Steel
Galvanized iron	Neutral	No	Steel
	Slightly oxidizing	Yes	Bronze
Cast iron, gray	Neutral	Yes	Cast iron
	Slightly oxidizing	Yes	Bronze
Cast iron, malleable	Slightly oxidizing	Yes	Bronze
Cast iron pipe, gray	Neutral	Yes	Cast iron
	Slightly oxidizing	Yes	Bronze
Cast iron pipe	Neutral	Yes	Cast iron or base metal composition
Chromium-nickel steel castings	Neutral	Yes	Base metal composition or 25-12 chromium-nickel steel
Chromium-nickel steel (18-8 and 25-12)	Neutral	Yes	Columbium stainless steel or base metal composition
Chromium steel	Neutral	Yes	Columbium stainless steel or base metal composition
Chromium iron	Neutral	Yes	Columbium stainless steel or base metal composition

3.1.1.2 Arc Welding

The two common arc welding processes are referred to as Shielded Metal Arc Welding (SMAW), and Flux-Cored Arc Welding (FCAW).

The electric arc method of welding depends on the fact that, as electricity passes through a gaseous gap from one electric conductor to another, a very intense and concentrated heat is produced. The temperature of the arc jumping between the two conductors is of the order of 3600 - 3900°C. The most widely used method is metal electrode arc welding, referred to as shielded metal arc welding or "stick" welding, see Figure 1. An arc is produced between a metal electrode and the workpiece by connecting them to a direct current or an alternating current power supply. At the temperature of the arc, the workpiece and electrode melt and fuse, producing a weld. The open circuit voltage for welding may be up to 110 volts, but during welding the voltage across the arc is less than 40 volts and the consumable electrode is advanced to maintain a constant arc length. The power consumption, based on current and voltage, has been shown to correlate with the rate of fume generation.

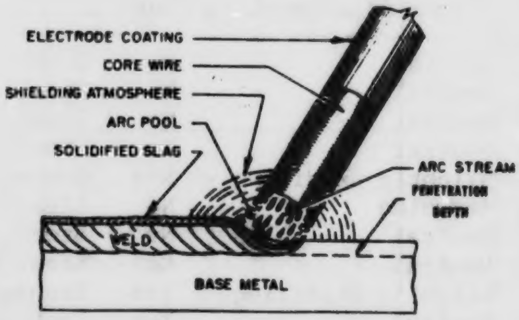

Figure 1 Shielded Metal-Arc Welding

The metallic electrode comprises a metal core which is compatible with the metal of the workpiece, and a flux coating. The most commonly used electrodes are made of mild steel, but other alloys include nickel steel, chrome-molybdenum steel, manganese-molybdenum steel, nickel-manganese-molybdenum steel, aluminum, copper-aluminum, lead-bronze and phosphor bronze. The flux coating surrounding the electrode core fulfils several purposes. Gas producing ingredients such as paper, cotton, wood flour, cellulose, starch and dextrin produce neutral or reducing gases like carbon monoxide and hydrogen which shield the molten metal and prevent oxidation of the weld. Flux ingredients such as titanium dioxide (rutile), calcium carbonate, magnesium carbonate, feldspar and mica promote fusion, remove impurities from the molten metal, and form a slag coating over the weld which controls the rate of cooling and prevents atmospheric oxidation of the hot metal. Some special electrodes have metallic salts included in the covering to produce the correct alloy metal in the weld. Hydrogen has harmful effects on alloy steels, causing inter-granular cracks and, in welding applications involving these alloys, low hydrogen electrodes containing substantial quantities of fluorspar (calcium fluoride) and sodium fluoride in the coatings are used to react with hydrogen and exclude it from the melt. Hydrogen capture by calcium fluoride produces hydrogen fluoride as a component of the welding fume.

In FCAW, shielding is provided by a flux contained within the tubular electrode and may be supplemented by an externally supplied gas. The feature that distinguishes the FCAW process from other arc welding processes is the enclosure of fluxing ingredients within a continuously fed electrode.

Flux-cored arc welding offers two major process variations that differ in the method used to shield arc and weld pool from atmospheric contamination (oxygen and nitrogen). One type, self-shielded FCAW, protects the molten metal to some extent through the decomposition and vaporization of the flux ore by the heat of the arc. The other type, gas shielded FCAW, makes use of a protective gas flow in addition to the flux core action to shield the arc and the weld pool. With both methods, the electrode core material provides the solidifying weld metal.

Flux-cored arc welding is usually applied as semiautomatic welding, where the gun is hand-held and manipulated by the welder. The process is also used in machine welding, where the operator continuously monitors the operation during mechanized travel. Automatic welding is also applied, as in the automotive industry, where light-gage body parts and casings are welded with push-button control.

The benefits of flux-cored welding are achieved by combining two general features:

1. The productivity of continuous welding, and
2. The metallurgical benefits that can be derived from a flux. In this respect FCAW possesses some of the characteristics of shielded metal arc welding (SMAW), gas metal arc welding (GMAW), and submerged arc welding (SAW).

Metal arc welding has very extensive application in the fabrication of mild steel structures and, because of the wide range of metal alloy electrodes and flux covering available, may be used with chromium steel, nickel-chromium steel, chrome-nickel-molybdenum steel, galvanized steel (mild steel plated with zinc which is deposited electrically, by spray, or by dipping), cast iron, copper, brass and bronze.

3.1.1.3 Inert Gas - Arc Welding

The two principal types of inert gas welding are Gas Metal-Arc Welding (GMAW) or Metal Inert Gas Welding (MIG), and Tungsten Inert Gas Welding (TIG), also known as Gas Tungsten-Arc Welding (GTAW).

In both these processes the electrode holder or torch is designed to supply a flow of inert (i.e. chemically unreactive) gas, such as carbon dioxide, helium or argon, which surrounds the electric arc to exclude oxygen and other atmospheric contaminants from the molten metal pool. Inert gas welding is not only a fast and clean process but, by eliminating oxygen and other impurities, welds are possible on metals which are impractical or very difficult to weld using other arc welding methods. The TIG welding process uses a non-consumable tungsten electrode mounted in a special electrode holder through which inert gas flows so as to surround the electrode and arc. Where required, filler metal is supplied by a rod of the same composition as the base plate. In the MIG welding process, a consumable metal electrode is fed through the electrode holder and into the arc where it is melted and deposited in the weld. Electrodes are normally supplied in the form of wires wound on special reels or spools. By means of an adjustable speed electric motor activated by a trigger mechanism on the torch, the spool feeds wire into the arc at a rate equal to the rate of

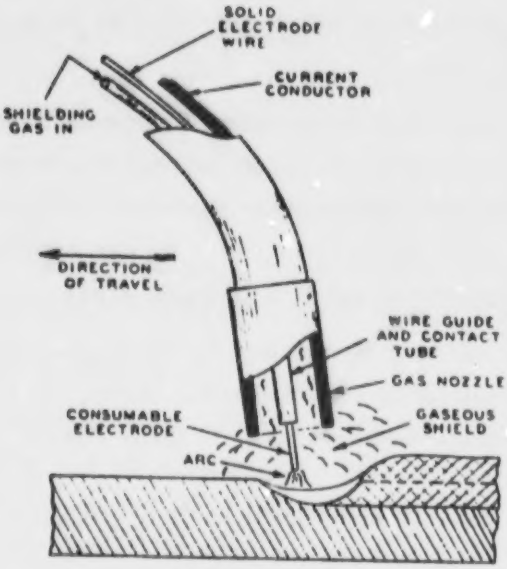
SOLID ELECTRODE WIRE
CURRENT CONDUCTOR
SHIELDING GAS IN
DIRECTION OF TRAVEL
WIRE GUIDE AND CONTACT TUBE
GAS NOZZLE
CONSUMABLE ELECTRODE
GASEOUS SHIELD
ARC

Figure 2. Diagrammatic Sketch of Gas Metal-Arc Welding

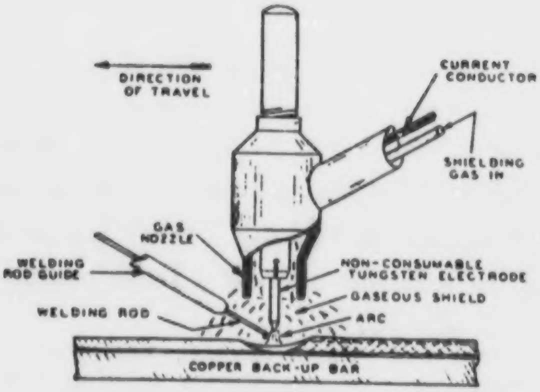
DIRECTION OF TRAVEL
CURRENT CONDUCTOR
SHIELDING GAS IN
GAS NOZZLE
WELDING ROD GUIDE
NON-CONSUMABLE TUNGSTEN ELECTRODE
GASEOUS SHIELD
WELDING ROD
ARC
COPPER BACK-UP BAR

Figure 3. Diagrammatic Sketch of Gas Tungsten-Arc Welding

deposition. The main types of consumable electrode are a simple bare wire and a flux-cored electrode in which the wire is in the form of a tube filled with welding flux.

The most popular shielding gases for gas-arc welding, namely helium, argon and carbon dioxide, may be used either in the pure form as, for example, in the argon-arc welding of aluminum, or in the form of mixtures such as the 20 per cent carbon dioxide : 80 per cent argon combination employed in fast production welding of mild steel.

While almost any metal can be welded by the inert gas-arc process, it is particularly suitable for stainless steel, aluminum and aluminum alloys, copper, copper-nickel alloys, bronze, brass, titanium and titanium alloys, and zirconium.

3.1.1.4 Resistance Welding

The fundamental principle upon which resistance welding is based is that resistance to the flow of an electric current through a conductor produces heat. When an electric current is passed through two pieces of metal that are touching, the locally created high resistance at the point of contact produces a high temperature and, if enough current is used, the contact surfaces will become plastic. If pressure is applied to the two pieces of metal, the plastic surfaces will fuse to form a weld.

A resistance welding machine is basically an electrical step-down transformer operating from an alternating current circuit which produces a very high current at a relatively low voltage. The workpieces to be joined are held together in contact between two electrodes which apply a weld pressure while the current is flowing. After the metal reaches the plastic state, the current is switched off and a forge pressure is applied to the electrodes until the weld solidifies.

There are many types of resistance welding operations based on the fundamental resistance principle and differing only in the preparation of the workpieces and the method of applying pressure. Some of the more important are:

(i) Spot Welding

Metal surfaces are lapped and held between electrodes of a small cross sectional area resulting in fusion at a particular spot. This operation is repeated at a number of locations by moving the lapped areas of the workpiece through the electrodes or by the use of multiple electrodes.

There is a portable form of spot welding in which caliper electrode clamps are moved across the stationary workpiece.

(ii) Flash Welding

A form of butt welding which uses considerable pressure to join the workpieces together when the contacting surfaces have reached the plastic state. The high pressure forces fuse metal and slag out of the joint causing sparks or a flash. This welding method is used extensively in production work, particularly in the welding of pipes and rods.

(iii) Seam Welding

This produces a continuous or intermittent seam weld near the edge of two overlapped workpieces which are squeezed between two roller electrodes. As these rollers travel over the metal, the current passing between them heats the two pieces of metal to the fusion point.

By using the correct combination of electrode properties, including good electrical and thermal conductivity, appropriate mechanical strength and hardness, and minimum tendency to alloy with the metal forming the workpiece, the resistance welding process can be applied to galvanized irons, mild steels, low alloy steels, stainless steels, aluminum and aluminum alloys, magnesium alloys, brass, bronzes, and nickel alloys.

3.1.2 Soldering and Brazing

Soldering and brazing, which are essentially one and the same process, are somewhat arbitrarily distinguished on the basis of the melting point of the material used to join the workpieces together. Thus, when two base metals which are not melted are joined by a molten third metal which has a melting point below 427°C (800°F), the process is called soldering, e.g., the joining of copper to steel using a lead-tin alloy. Brazing is done when two base metals which are not melted are joined by a molten third metal having a melting point above 427°C, as in the joining of two pieces of steel with a silver alloy.

3.1.2.1 Soldering

In the soldering process, the base metal is raised to the temperature at which the joining metal melts. Solder, in the form of a stick wire, is applied to the hot metal and allowed to flow between the surfaces to be joined which, on cooling, each form strong adhesion bonds with the joining metal.

Joints to be soldered must be free of oxides, grease and dirt. Fluxes, usually based on zinc chloride-ammonium chloride mixtures, or hydrochloric acid, are used for this purpose. Solder wire with flux core is also used.

Heat is provided for the soldering process by means of a soldering copper bit, either gas or electrically heated; air-gas or oxy-gas torch; furnace or a carbon arc. Alternatively, metal surfaces to be joined may be dipped into a bath of molten solder.

Common soft solder alloys consist of mixtures of tin and lead which sometimes have small amounts of other metals (antimony, bismuth, silver) to produce special properties. Lead-silver solders or tin-antimony solders are used when higher strength joints are desired. For high temperature applications, a 95 per cent cadmium and 5 per cent silver solder is employed.

The appropriate choice of solder alloy permits the soldering of tin, copper and its aluminum and beryllium alloys, brass, bronze, galvanized iron, sheet iron, stainless steel and aluminum.

3.1.2.2 Brazing

Brazing is an adhesion process in which the metals being joined are heated, but not melted, and the brazing filler metal melts and flows at temperatures above 427°C. A brazed joint is stronger than a soldered joint and, in certain instances, as strong as a welded joint.

In the brazing process, the base metals are heated to dull redness and the brazing rod is brought into contact with the hot surfaces, where it melts and flows into the joint.

Many filler metal alloys are available for use in brazing and braze welding, including copper-zinc alloys; copper, nickel and chromium alloys containing up to 24 per cent of cadmium; copper and gold alloys; aluminum and silica alloys, and magnesium alloys.

Depending on the nature of the base metals, a brazing flux based on borax-boric acid mixtures, sometimes containing phosphorus and halogen salts, or sodium cyanide, is used to clean the surfaces to be joined by applying it either to the filler rod or directly to the joint.

Heat sources for brazing may be provided by a molten bath of brazing metal into which the base metals are dipped, an air-gas or oxy-gas torch, a controlled atmosphere furnace, electrical resistance, electrical induction, or carbon arc.

The brazing process is suitable for joining copper, brass, bronze, aluminum alloys, magnesium alloys, cast and malleable iron, steel and stainless steel.

3.1.3 Arc and Flame Cutting

The types of metal cutting most commonly used in industry today are Gas Cutting and Arc Cutting.

3.1.3.1 Gas Cutting

In the oxyacetylene process, an oxyacetylene flame is used to heat the metal and an oxygen jet is applied to perform the cutting. The heating flame which, in an oxyacetylene torch issues from several orifices arranged in a circle around a central oxygen orifice, heats a spot on the surface of the workpiece to a temperature of approximately 1000°C. At this point the oxygen jet is turned on and the exothermic oxidation reaction melts the metal oxide formed, and this is blown away by the jet.

The oxyacetylene torch is particularly suitable for cutting metals whose oxides have a lower-melting temperature than the metal itself. Practically all steels fall into this category. However, metals like cast iron, stainless steel and non-ferrous metals, whose oxides have a higher melting temperature than the metal itself, are difficult to cut cleanly with oxyacetylene and respond better to alternative arc-cutting processes.

3.1.3.2 Arc Cutting

The intense heat of the electric arc makes it possible to melt very small areas of metal surface, and if the fluid metal can be made to flow away by gravity or gas pressure then the metal will be effectively removed leaving a clean cavity or cut.

Many metals, including cast iron, may be successfully cut using the carbon electrode arc (carbon arc) as a heat source, the molten metal being removed by gravity.

Metal may also be removed with the electric arc from covered metal electrodes. Most cutting electrodes use a covering that disintegrates at a slower rate than the metal core, thus creating a deep recess at the arc end of the electrode and producing a jet action that tends to blow the molten base metal away. Such electrodes may be used for cutting stainless steel, aluminum, copper, bronze, nickel, cast iron, manganese steel or alloy steels.

If molten metal can be blown away by an air jet as the electric arc creates the molten pool, a cut or gouge will be quickly and efficiently formed. This principle is embodied in the Air Carbon-Arc Cutting process (Arc Air Gouging). Copper-sheathed carbon or graphite electrodes are used, and compressed air fed to an orifice built into the electrode holder creates an air jet which blows the molten metal away.

The Oxygen-Arc Cutting process makes use of a tubular metal-covered electrode through which a flow of oxygen is passed into the arc. This process is thus a combination of electric arc cutting and oxygen cutting, and is mainly used for cutting metals not suitable for the oxyacetylene process.

3.1.4 Metal Spraying

Metal spraying or metallizing is a process for applying protective coatings principally to iron and steel, see Figure 4. Commonly-used spray metals are aluminum, copper, lead, nickel, tin, zinc and various alloys.

The coating metal is brought into contact simultaneously with heat from an oxy-gas flame (about 2760°C) and compressed air. For manual operations, this mixing is carried out in a hand-held spray gun. The spray metal is thus melted, atomized, and projected at high velocity onto the surface to be coated. The spray metal is supplied on a continuous basis from a wire coil or, in the case of high melting point or hard alloy coatings, in the powder form.

Metal spraying is carried out mainly for protective coating, for building up surfaces (e.g., salvage of out-of-tolerance components) and the application of mechanical friction surfaces to bearings. In protective coating applications, the most common procedure is the field application of zinc to structures such as steel bridges, storage tanks, pylons etc. For special equipment used in the chemical, petrochemical and foodstuffs industries, anti-corrosion coatings of lead, aluminum, silver or stainless steel are commonly used. Machine or engine wearing parts such as light alloy pistons are sprayed with steel or hard alloy coatings. The electronics and telecommunications industries use metal spray techniques on a refined scale for making non-metallic materials electrically conductive.

3.2 Health Hazards - Welder's Exposure to Fume

This section discusses the known health effects of various components found in fume arising from the great majority of welding processes in use at the present time.

Whilst there are data available to provide an understanding of the effects of certain individual components, such as lead and zinc fume, the health implications of exposure to total welding fume made up of a wide variety of substances does not appear to be adequately documented.(1,2)

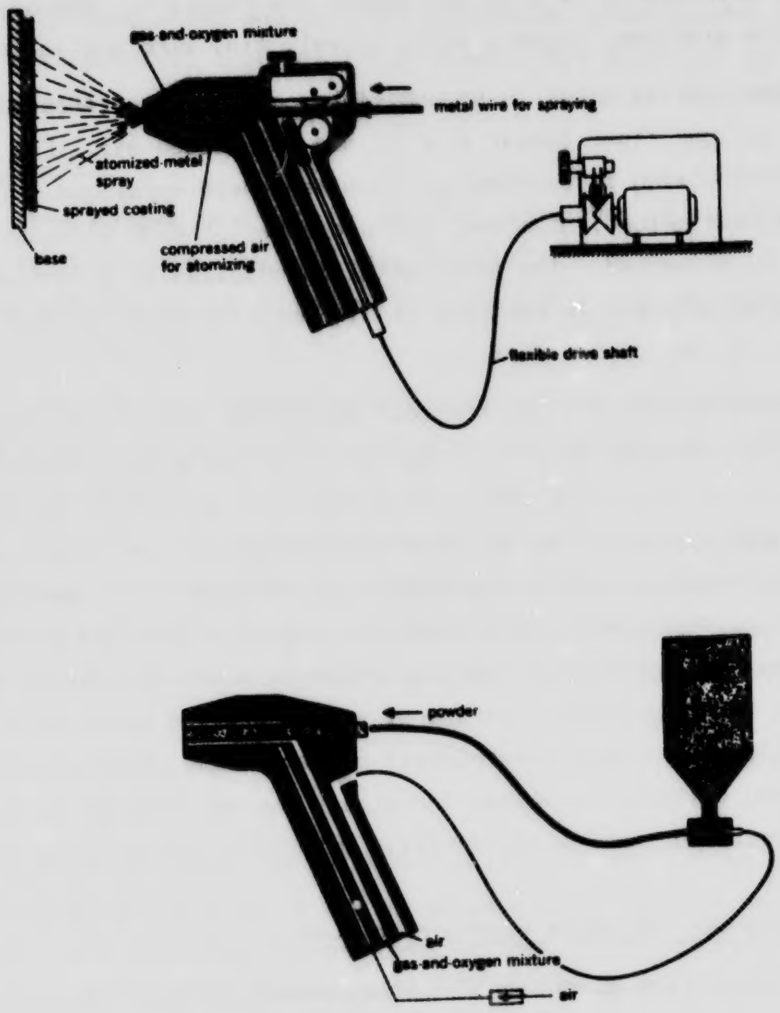
gas-and-oxygen mixture
metal wire for spraying
atomized-metal spray
sprayed coating
base
compressed air for atomizing
flexible drive shaft
powder
air
gas-and-oxygen mixture
air

Figure 4. Metal Spray Gun

The failure to report on the precise nature of fume composition and exposure is found to be quite common in health studies of welding populations. This omission has resulted in conflicting inferences on causal relationships between fume and health effects but has not dissuaded investigators from stating their suspicions that there may be substances in welding fume which have acute, sub-acute and chronic irreversible effects at certain body organ sites, notably the lungs.

The number of welding and associated processes (including brazing, soldering, flame cutting and metal spraying) identified by the American Welding Society is over 80. Any definitive study of welder's occupational health should therefore take into consideration the toxic nature and exposure level for the particular substances occurring in the operations to which the welder is exposed.

In evaluating the risk associated with exposure to hazardous materials in the workplace, a number of factors have to be considered in addition to the toxicity of the materials present. A toxic substance does no harm whatsoever if it is safely kept completely away from the worker. Obviously, if this is the case, not much work would be done. Industrial hygiene must therefore provide practicable guidelines for controlling the degree of contact between the worker and the toxic materials he works with in a manner which will allow the job to proceed. The extent of control required for airborne contaminants in the welding environment depends upon an evaluation of the factors shown in Table 4.

A few points may be added with respect to hazard evaluation procedure. In arc welding, since the base metal weld pool is much cooler than the electrode tip, the hazard contribution from the base metal is only of concern when this contains volatile alloying elements, or a volatile and toxic coating, such as leaded paint.

A standard test procedure for the assessment of toxicity of paint primer thermal decomposition products released during welding and cutting has been developed by the Welding Institute (U.K.)(3). This lays down test chamber parameters for the comparative investigation of fume generated in welding paint-primed versus bare metal steel plate. A

TABLE 4

FACTORS IN RISK EVALUATION

RISK EVALUATION PROCEDURE	FACTORS FOR CONSIDERATION
Identify hazardous materials in the work environment.	Fume from base metal and filler rod or electrode; flux materials, workpiece coating materials, residual cleaning solvents, paint coatings. Type of oxy-fuel used. Oxides of nitrogen, carbon monoxide, ozone.
Establish toxicity of materials, leading to the setting of maximum permissible concentrations in the breathing zone.	Metal fume, metal oxide dust, chemicals used in the flux, fluorides, pigments used in paint coverings, solvent vapors. Establish time-weighted-average and short term exposure TLV's. Check ceiling values of TLV's. Investigate combined effects of composite fume.
Evaluate work practices and welding procedures in order to understand the manner in which toxic materials become a health hazard.	Arc welding - current voltage, polarity, electrode diameter, rate of weld deposition. Gas welding - fuels used, combustion products, partial combustion products.
Develop a statement of risk based on practices, procedures and maximum permissible concentrations.	General - rate of weld deposition, workpiece size and shape, ventilation effectiveness, duty cycle and exposure time, use of respirators. Techniques of individual welder; face close to arc? Use face-shield effectively? Enclosed space welding technique.
Use control measures to eliminate the risk by maintaining exposure to toxic materials below the maximum permissible concentrations.	Engineering controls; change work practices; substitute less hazardous materials; personal protection e.g., respirators.

laboratory simulation of workshop conditions is described,and the Welding Institute provides the manufacturer of the coating material with a hazard evaluation report valid for five years, and contingent upon their being no change in coating formulation during that period.

Other hazards arising from secondary sources include the decomposition by ultraviolet radiation of chlorinated hydrocarbon solvent vapors to produce phosgene. A comprehensive list of substances taken from the British Factory Inspectorate Technical Data Note 2/74, and likely to be found in most welding, cutting, brazing, soldering and metal spraying situations, is presented in Table 5.

Figure 5 illustrates the occurrence of the principal gaseous and particulate matter components of welding fume.

Among the substances of particular concern are cadmium, cobalt, silver, vanadium, beryllium, chromium and manganese.

Alloys, such as high chromium steel, giving rise to water soluble chromium ion complexes in various oxidation states require special consideration in the welding workplace due to the suspected carcinogenicity of these components.

At least two recent studies address the question of determining the hexavalent chromium content of welding fume; one from the Danish Welding Institute, Jan. 1979(4) and the other a thesis submitted to the University of Toronto Department of Chemical Engineering, 1979(5).

The first study describes a high efficiency recovery method for assessing chromium VI by pH control using carbonate leaching. The problem being addressed here is the presence of autoredox systems in the sample composition, leading to false readings due to the oxidation or reduction of chromium VI present originally in the sample taken at the welding site.

The second study addresses the determination of chromium VI produced in the shielded metal arc welding of 308 stainless steel. Concern is expressed that the proposed lowering by the U.S. Occupational Health and Safety Administration (OSHA) of the maximum permissible concentrations of

TABLE 5

HAZARDOUS MATERIALS IN WELDING

Metals and Compounds	TLV, mg/m^3	
Beryllium (Be)	0.002	*
Cadmium oxide fume (as Cd)	0.05	C
Calcium oxide (CaO)	2	
Chromic acid and chromates (as CrO_3)	0.05	**
Chromium, soluble chromic and chromous salts (as Cr)	0.5	
Cobalt, metal fume, and dust (Co)	0.05	
Copper fume (Cu)	1	
Copper dusts and mists (Cu)	1	
Fluoride (as F)	2.5	
Iron oxide fume	5	
Lead (Pb), inorganic compounds, fumes and dusts	0.15	
Magnesium oxide fume (Mg)	10	
Manganese and compounds (as Mn)	5	C
Mercury (Hg), except alkyl forms	0.05	
Molybdenum (Mo): soluble compounds	5	
insoluble compounds	10	
Nickel (metal)	1	
Silver (metal)	0.1	
Tin, inorganic compounds except SnH_4 and SnO_2 (as Sn)	2	
Tin oxide (as Sn)	E	
Titanium dioxide (Ti)	E	
Tungsten and compounds (as W): soluble	1	
insoluble	5	
Vanadium (V_2O_5) as V: dust	0.05	
fume	0.05	
Zinc oxide fume (as Zn)	5	
Nuisance particulates	10	

Gases and Vapours	TLV, ppm	
Acetaldehyde, CH_3CHO	100	
Acetylene, C_2H_2	F	
Acrolein, CH_2CHCHO	0.1	
Argon, Ar	F	
Carbon dioxide, CO_2	5000	
Carbon monoxide, CO	50	
Helium, He	F	
Hydrogen Chloride, HC1	5	C
Hydrogen Fluoride, HF (as fluorine)	3	
Nitric oxide, NO	25	
Nitrogen dioxide, NO_2	3	C
Ozone, O_3	0.1	
Phosgene, $COC1_2$	0.1	
Propane, C_3H_8	F	
Trichloroethylene, $CHC1CC1_2$	50	

Notes: C = ceiling limit
E = nuisance particulates
F = simple asphyxiants
* = suspected carcinogen
** = recognized carcinogen

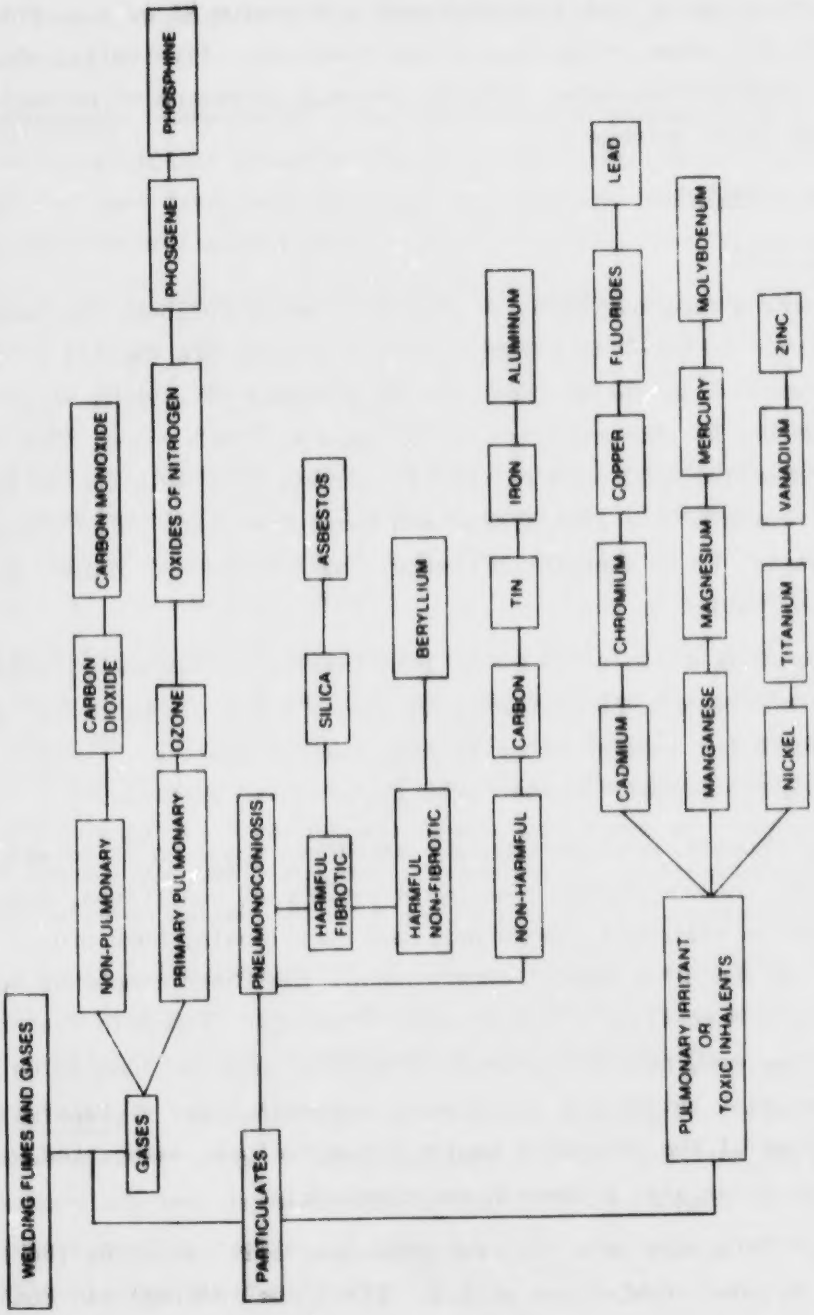
WELDING FUMES AND GASES
GASES
NON-PULMONARY
CARBON DIOXIDE
CARBON MONOXIDE
PRIMARY PULMONARY
OZONE
OXIDES OF NITROGEN
PHOSGENE
PHOSPHINE
PARTICULATES
PNEUMONOCONIOSIS
HARMFUL FIBROTIC
SILICA
ASBESTOS
HARMFUL NON-FIBROTIC
BERYLLIUM
NON-HARMFUL
CARBON
TIN
IRON
ALUMINUM
PULMONARY IRRITANT OR TOXIC INHALENTS
CADMIUM
CHROMIUM
COPPER
FLUORIDES
LEAD
MANGANESE
MAGNESIUM
MERCURY
MOLYBDENUM
NICKEL
TITANIUM
VANADIUM
ZINC

Figure 5. Principal Gases and Particulates in Welding Fume

"carcinogenic" and "non-carcinogenic" chromium VI to 1 μg/m^3 and 25 μg/m^3 respectively would be unnecessarily costly to industry. The distinction between carcinogenic and non-carcinogenic chromium VI made in this study, rests with the water solubility of the compound. (Typically, chromates of zinc and lead are non-water soluble, whereas chromates of potassium and sodium are water soluble.)

3.2.1 Particulate Matter

3.2.1.1 Pneumoconioses

Welding fume particles which, with few exceptions, are smaller than 1 μm are said to be of respirable size, i.e. they are capable of penetrating the lung airways as far as the terminal air sacs of alveoli where they may be transported by phagocytic cells to regional lymph nodes. The more soluble particles will pass relatively quickly into solution in the extracellular fluids of the lung tissue and be widely distributed throughout the body, possibly to be excreted ultimately by the kidneys either unchanged or after detoxication by the liver.

Particles which are more or less insoluble even when finely divided will remain in the lungs or the lymph channels and glands draining the lung area. Should the inhaled material have toxic properties, serious harm can result from the deposition and retention of these particles.

The deposition of particulate matter in the lung is termed pneumoconiosis. The pneumoconioses comprise a variety of conditions, some of which, such as silicosis, asbestosis and berylliosis, have proved to be harmful. On the other hand, certain metals and their compounds appear to be inert when deposited in the alveoli or related lymphatic drainage system. They can, however, produce changes within the lung which are radiographically detectable and closely resemble those of harmful pneumoconiosis. Some of the so-called benign pneumoconioses associated with welding are siderosis, stannosis and aluminosis.

Silicosis: Silicosis is a fibrotic pneumoconiosis caused by the inhalation of finely divided crystalline silica. Electrode coatings can contain large amounts of silica, ferrosilicate or other silicates, and substantial amounts of amorphous silica and silicates can appear in the welding fume. No free crystalline silica is found in welding fumes, however, and the occurrence of silicosis due to welding is thought to be out of the question.

Asbestosis: Asbestosis is another fibrotic pneumoconiosis resulting from the deposition of asbestos fibres in the lung. While formerly a constituent of some electrode coatings, this has now been almost totally replaced by less harmful substances.

Berylliosis: Beryllium poisoning may involve many organs, but its principal effects are on the lungs. Present usually to the extent of 1-2 per cent in beryllium - copper alloys, acute exposure to high concentrations of this metal can result in chemical pneumonia, and long-term exposure can produce shortness of breath, chronic cough, and significant weight loss accompanied by fatigue and general weakness. The hazards associated with the handling and joining of beryllium and its alloys are generally well known in the welding industry.

Siderosis: Simple siderosis is caused by the inhalation of relatively pure iron oxide as a fine particulate fume produced during the welding or cutting of ferrous metals. Siderosis has long been assumed to be benign, but there have been reports of subjects with welders' siderosis who have both respiratory symptoms and severe impairment of lung function. In some of these symptomatic subjects, histological examination of the lungs has demonstrated marked fibrosis and, occasionally, emphysema.

Stannosis: The inhalation of tin-oxide dust over a long period of time will produce a benign pseudonodulation of the lungs known as stannosis; it is considered to be nonprogressive and nondisabling.

Aluminosis: The inhalation of aluminum oxide gives rise to a condition known as aluminosis or aluminum lung. This condition was not thought to produce any long-term adverse health effects in man, but recent investigations into the practice of aluminum prophylaxis in miners at risk from silicosis may prove otherwise.

The majority of the metal components contained in welding fume do not produce radiographic changes in the lungs, but their effects, where they occur, categorize them as pulmonary irritants, systemic toxins, or producers of metal fume fever. Some metals occupy more than one category.

Metal Fume Fever: Metal fume fever, sometimes called welder's ague, is an acute disability of short duration. The symptoms begin some hours after exposure. Intense headache, arising of muscles and rigors characterize the clinical picture. There may be a rise in temperature and an associated leucocytosis. The symptoms subside within 12-24 hours, leaving a feeling of weakness but no sequelae. It is thought that the illness is due to deposited fine particles of metal oxide in the lung combining with tissue protein to cause an antigen-antibody reaction. Some immunity is acquired on continued exposure but this is lost during short absences from work. It is now known that many metals can cause the syndrome; copper, zinc and magnesium being the commonest of these, but aluminum, antimony, cadmium, iron, manganese, nickel, selenium, silver and tin may also be implicated.

3.2.1.2 Specific Fume Effects

Copper: Acute intoxication in the form of metal fume fever occurs in welders exposed to copper fumes in welding, brazing and cutting of copper, brass and bronze materials. Copper fume can also produce irritation of the upper respiratory tract, a sweetish metallic taste, and gastrointestinal disturbances.

Magnesium: There is no evidence that inhalation of magnesium fume has led to lung injury, but magnesium oxide can cause the typical reaction of metal fume fever if inhaled in sufficient quantity.

Cadmium: Cadmium fume is generated during the cutting or welding of cadmium-coated metals, or the use of silver-cadmium solder in silver brazing processes. In non-fatal acute intoxication, intensity of the respiratory distress may increase for a few days, followed by recovery in 8-14 days. Death may occur as a result of severe pulmonary edema or renal cortical necrosis. Chronic exposure to cadmium fume is believed to produce an insidious but eventually crippling form of pulmonary damage or renal injury.

Chromium: Chromium exposure in welders may constitute a significant health hazard, but whether these workers are exposed to hexavalent or trivalent compounds is not known. The oxidation of chromium alloys produces fumes which cause irritation of the upper and lower respiratory tracts. Hexavalent chromium compounds are also implicated in the production of bronchial carcinoma.

Lead: The welding or cutting of leaded steels and lead primed or painted steels gives rise to high atmospheric concentrations of lead. The clinical picture of lead poisoning is well documented, early symptoms of intoxication being fatigue, sleep disturbance and constipation. More prolonged and severe exposure may be followed by colic, anemia, neuritis and encephalopathy.

Manganese: Manganese is a constituent of many steels, alloys of copper, aluminum, magnesium and cast iron. The flux coatings of certain electrodes used to weld armour steels may contain up to 17-18 per cent manganese. Manganese fume generated by welding and cutting processes can, in acute exposure, cause manganese pneumonitis. This is an acute alveolar inflammation causing severe breathlessness and cyanosis. Heavy exposure to freshly formed manganese fume can result in metal fume fever, but in its chronic form manganese poisoning is primarily a psychic and neurological disorder with symptoms of weakness, excessive salivation, facial paralysis, difficulty in walking, and impaired speech.

Mercury: Mercury compounds are used to coat metals to prevent rust, and as anti-fouling agents in marine paints. Under the intense heat of the arc or gas flame, mercury vapors will be produced and exposure to these vapors may produce gastrointestinal disorders, kidney damage, emotional instability and injury to the nervous system.

Nickel: Present in the welding fumes from stainless steels and cupronickel alloys, nickel compounds can produce severe pneumonitis and dermatitis. There have also been reports of cancer of the respiratory tract due to the inhalation of nickel compounds.

Titanium: A major constituent of the coatings of rutile electrodes and of welding fumes, titanium is not regarded as being highly toxic to human beings. It has been reported, however, that high concentrations of titanium dioxide dust may produce irritation of the respiratory system.

Vanadium: Vanadium is present in some welding filler wires, in vanadium steels, and as a constituent of electrode coatings. Vanadium pentoxide fume is very irritating to the mucous membranes of the eyes and respiratory tract causing bronchopneumonia and mild chronic bronchitis.

Fluorides: Fluoride compounds are found in several types of fluxes used in welding. The inhalation of fluoride fumes may produce respiratory tract irritation manifested by chills, fever, breathlessness and cough. Repeated exposures to high concentrations of fluoride fumes may, in the long term, cause pulmonary edema and bone damage.

Zinc: Exposure to zinc oxide fumes formed during the welding, brazing or cutting of galvanized metals may produce metal fume fever, or may give rise to irritation of the respiratory and gastrointestinal tract.

Silver: Exposure to silver produces a bluish black deposit of metallic silver in the skin, referred to as argyria. It is usually localized to those areas which have been in contact with the metal, but generalized argyria has been attributed to ingestion and inhalation. Respiratory tract argyrosis has been recorded, along with abnormal chest X-ray findings following exposure to silver dust. Some earlier reports of silver exposure suggest that kidney damage and arteriosclerotic changes may be induced. The current TLV of 0.01 mg/m^3 for soluble silver compounds is calculated to prevent generalized argyria by minimizing silver accumulation in the body based on a 20-year exposure span. Silver soldering is a risk occupation in this respect (associated with cadmium fume exposure).

3.2.2 Toxic Gases

Carbon Monoxide: Carbon monoxide may be formed in welding and cutting processes as a result of the incomplete combustion of fuel gases, the burning of resin mediums in metal primers, the burning of the carbon electrodes used in air carbon arc cutting, or the decomposition of carbon dioxide shielding gas in the inert gas-arc welding process. In the latter process, breathing zone concentrations of carbon monoxide have regularly been observed to exceed the Threshold Limit Value. The well-known effects of prolonged exposure to carbon monoxide are no different from the acute effects, namely headache, nausea, impaired senses, weakness, vertigo and ataxia.

Nitrogen Oxides: The temperature of welding and cutting processes is high enough to permit the direct oxidation of atmospheric nitrogen to nitric oxide and nitrogen dioxide. Very small amounts are formed in the electric arc welding process, larger amounts in the air carbon-arc cutting process, and dangerously high concentrations in oxy-acetylene flame which, under enclosed conditions, can produce a breathing zone concentration of 300 ppm in less than one hour. Nitrogen dioxide has poor warning properties and a disabling or even fatal dose may be inhaled without the affected person being aware of it. Symptoms are delayed for several hours after exposure, when the affected person experiences tightness in the chest, breathlessness and cough culminating in pulmonary edema which interferes with oxygen exchange. Death may occur from anoxia.

Ozone: Ozone is produced by ultraviolet radiation arising from arc welding and cutting operations. Substantial amounts of the gas are generated by the inert gas-arc welding of aluminum where argon is used as the shielding gas. Ozone is very irritating to all mucous membranes, with excessive exposures producing pulmonary edema. Other effects of exposure to ozone include headache, chest pain and eye irritation.

Ozone presents a special problem when considering ventilation methods of hazard control due to the fact that its production is not confined to the immediate zone of the arc. The generation of ozone can take place within a solid sphere of up to 1 metre(6) radius from the arc due to the gradual absorption by oxygen molecules of ultra-violet electro-magnetic energy.

Ozone generation, dispersion and control in welding has been fairly extensively studied(1,7,8,6) for purposes of establishing measurement techniques, ventilation criteria and personal protection requirements for respiratory exposure.

The development of procedures for ozone monitoring and control have been extensively studied by Hatch Associates on behalf of Canadian manufacturers of welded aluminum structures. Ozone control is discussed briefly in Section 7.

Phosgene: Phosgene is formed by decomposition of chlorinated hydrocarbon solvent vapors by U.V. radiation or heat from the welding arc. These vapors may originate from degreasing tanks in the welding shop or from traces of solvent retained by degreased metal parts. As with nitrogen dioxide absorption, there is a delay in the onset of symptoms in the exposed person, but by producing hydrochloric acid in the lungs it can cause pulmonary edema.

Phosphine: Phosphine or hydrogen phosphide is generated when steel coated with phosphate rustproofing is welded. The effects of phosphine include irritation of the eyes, respiratory tract and skin as well as damage to the kidneys and other organs. Chronic exposure may result in disturbance of sight and speech.

Acrolein: Acrolein is a thermal decomposition product of certain paint primer mediums, notably polyvinyl-butyral resins. Even at very low concentrations it is intensely irritating to the eye and respiratory tract.

3.3 Sources for Estimation of Population at Risk

3.3.1 Certification and Proficiency Records

In attempting to derive a figure for the total number of welders in Canada based on trade certification records, two immediate difficulties appear. Firstly, not all welders are required to be certified (in fact the great majority are not), and secondly, a person who welds may be listed in some other trade category; for example, as a mechanic.

This situation arises from the fact that, although welding is listed in the Canadian Classification and Dictionary of Occupations, Class 8335(9), it is not recognized nationally across Canada as a distinct trade, but rather as a "tool of the trade". Alberta, Saskatchewan, Manitoba, PEI, Newfoundland and the Northwest Territories are, in part, exceptions to this, where welding is, or is becoming, a formally recognized provincial trade classification. This definitive approach in Alberta, for example, is probably in response to special needs in pipeline manpower planning.

In Ontario, welders for building structures are hired as mechanics. In addition, there are boilermaker welders (pressure vessels) and carpenter welders (steel reinforced concrete work).

The following sections, 3.3.1.1 and 3.3.1.2, outline the situation, including some of the problems encountered in attempting a head count through certification records.

3.3.1.1 Certification Procedures: General

Across the country, boiler and pressure vessel welders are certified under provincial authority according to the ASME* Code, Section 9 - Pressure Vessels, or the related Canadian Code, the CSA Standard B51. Non-pressure vessel welders are qualified under the direct authority of their current employer, who is, in turn, certified by the Canadian Welding Bureau (CWB) to CSA Standards W47.1, Certification of Competence for Fusion Welding of Steel Structures or W47.2, Aluminum Welding Certification Code. Outside these instructions, there is little if anything in the way of widely recognized certification.

It appears, however, that some provinces are looking seriously at developing training and proficiency testing programs where the need is proven.

The CSA welding standards are frequently invoked in vendor-customer contracts, as well as in certain statutory regulations in the public domain, such as the National Building Code and provincial building codes.

In following through on records of CSA W47.1 and W47.2 certification, the counting of welders is frustrated by duplication and simultaneous documentation. The CWB certifies a company for the particular type of work carried out by that company and the employer holds the welder's licence for his duration of employment. Upon changing employment, the welder must be relicensed under the new employer if a different welding practice is involved. If the same practice is involved, a welder may carry a Welder Identification Transfer Card for lodging with the new employer. In either case, the welder is required to be tested every two years.

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* American Society of Mechanical Engineers

The CWB does maintain records of licensing tests for welders employed in this fashion, but since a welder may have a licence in more than one proficiency, and may also be tested under a number of different employers, these records cannot readily supply a figure for the number of welders involved.

In addition to CWB certified and Boiler and Pressure Vessel certified welding operations, railway equipment, aircraft manufacture and shipbuilding call for their own proficiency skills, discussed later.

The geographical distribution of 1236 CWB certified companies given in Table 6 is made up of those companies where welding procedures are carried out to CSA standards. For estimating the total number of certified welders in the Canadian labour force, however, a head count "at one point in time" within all these companies would provide useful but limited information since companies employing welders certified under Boiler and Pressure Vessel, railway or other specialty may not be included in Table 6. Conversely, welders certified outside the authority of the CWB may or may not be employees of the listed companies. Therefore, employer welding certification records would have to be interpreted with caution if they are to be used as a source for a welder population count.

For purposes of establishing a welding population data base, it appears that the current records of the CWB may be suitable for refinement and development.

TABLE 6

DISTRIBUTION OF COMPANIES CERTIFIED BY THE CANADIAN WELDING BUREAU UNDER CSA STANDARDS W47.1 AND W47.2

ZONE:	PACIFIC	ALBERTA	MIDWEST	ONTARIO	QUEBEC	ATLANTIC	TOTAL
Operations							
Steel Structures	122	80	90	556	242	49	1139
Aluminum Structures	6	1	6	27	24	4	68
Concrete Reinforcing	3	3	3	10	2	0	21
Resistance Welding	1	0	1	4	2	0	8
TOTALS	132	84	100	597	270	53	1236

Outside the domain of CSA and ASME proficiency standards, welders in industries associated with aircraft, shipyards and railways must meet a standard of competence defined by the special requirements of these industries.

Airframe involvement requires proficiency standards derived from the Air Force. The code is referred to as POC 101/8 and would appear therefore to be a standard enforced under the authority of the Department of National Defence. Numbers of welders certified on airframe work can be expected to be relatively few.

Shipyard welders are certified according to standards set by Lloyds of London, the American Bureau of Shipping or the Canadian Coast Guard. The testing procedures are carried out by the employer, and welding work is surveyed by local representatives of the regulatory bodies themselves. There does not appear to be a central registry of welders thus certified. In addition, there is a high rate of turnover in shipyard welders, and we could expect frequent recertification procedures to further confuse the issue.

There are 27 railway companies operating in Canada of which three are U.S. companies with leased track. Canadian National welder certification methods are, as would be expected, representative of the approach to railway welder proficiency testing. For track, bridge, signal and work equipment welding, the company trains and certifies its own welders based upon standards of the American Welding Society. There is no evidence of a central record of railway welder certification which could be used to define populations. However, since there are only a few readily identifiable employers, welders in the railway sector can quite easily be counted and evaluated in terms of fume exposure and medical profile.

In the rolling stock private sector, welders are qualified similarly to those employed by the railways. The proficiency codes are derived from the American Association of Railroads, and testing of welders is carried out by employers, again with no central records of certification.

The Welding Institute of Canada has provided an estimate of about 60 000 persons in Canada engaged in some type of welding, brazing, or flame cutting activity. (A comparative figure for the USA is approximately 700 000.) From the 1971 Canada Census(10), the figures were: Welders and flamecutters, male 58 535; female 2790. Total: 61 325.

In 1979, the WIC awarded approximately 200 diplomas for their welding home study course. A failure rate of around 50 per cent is indicated, which suggests that some 400 students attempted the examination. Furthermore, it was pointed out that there are many students on the register who do not take the examination in their year of enrollment and are carried over from year to year. A more rigorous study of the Canadian welder population could well draw upon the resources of the WIC, since this organization is building up an impressive reference centre to complement its established expertise in welding research, practice and education.

We are advised that the WIC diploma is associated with the proficiency level required of welders who are employed by companies certified by the Canadian Welding Bureau.

A measure of the WIC's involvement with employers of welders is obtainable from their list of corporate members and from the response and attendance at a Health and Safety Seminar held in Toronto in 1977. This seminar was presented under the auspices of the Canadian Welding Society which is now incorporated along with the Canadian Welding Development Institute under the consolidated WIC (May 1979).

The task of allocating a study population of welders to defined areas of risk related to process, for future epidemiological studies, can be expected to be difficult. Based on those companies belonging to the WIC, some guidelines for defining risk environments could be obtained from the categories contained in member company records. Under the heading "Processes Utilized", the following 18 areas of process, and hence of type of occupational health environment, are recorded:

01 Brazing and cutting
02 Gas welding
03 Gas cutting
04 Shielded metal-arc welding (SMAW)
05 Gas tungsten arc welding (GTAW)
06 Gas metal-arc welding (GMAW)
07 Submerged arc welding
08 Friction welding
09 Resistance welding
10 Thermit welding
11 Electric-plug welding
12 Electric-gas welding
13 Plasma welding
14 Plasma cutting
15 Electron beam welding
16 Laser welding
17 Laser cutting
18 Other

3.3.1.2 Provincial Certification

The number of Boiler and Pressure Vessel certified welders in Canada represents only a small portion of the total. The inspectorates in each province were contacted in an attempt to derive a national total for this category of welder. It was found that although data on the number of proficiency tests given is readily available, identification of persons certified is not. In most cases, the inspectorates stated that the names of welders could be extracted by manual methods, though this would be time consuming and costly.

However, bearing in mind that one of the objectives of this study is to identify potentially useful channels for establishing a sample of the welding population for closer study, the B & PV certified sector does appear to keep better records than are found in other areas of welding proficiency and certification. This is understandable because of the need for safety protection addressed in the CSA Standard B51 -- Code for the Construction and Inspection of Boilers and Pressure Vessels or the ASME Boiler and Pressure Vessel Regulations.

Details of the provincial bodies and pressure vessel legislation are presented in Section 4.2.

The following pages summarize the information obtained from the provincial inspectorates. The best available estimates for welders are given in Table 7.

British Columbia - Ministry of Labour
- Boiler and Pressure Vessel Safety

B & PV certified welders are not identifiable by name or total number. A data processing system is being planned which will provide this data in the future. B & PV welders will carry a logbook which will assist in keeping track not only of their employment experience, but also of the type of fume exposure and exposure duration (rounded off to units of employment periods).

Additional information provided by the B & PV Branch indicates that there are 16 949 welders certified with a DPW Ticket. This refers to certification of welders carried out by the Department of Public Works, Safety Services Engineering Division, a procedure no longer in operation. Also, DPW certification may or may not include those welders certified by CWB approved employers.

The Apprenticeship Branch of the Ministry of Labour advises that, associated with the transfer of the Safety Services Engineering Division to the Ministry of Labour, government certification of welders has been rescinded pending debate on making welding a formal apprenticeable occupation in the province.

At the present time, therefore, it appears that government sources for estimating the number of welders in B.C. are not readily accessible. However, the Ministry has indicated that it will attempt further data retrieval upon receipt of a written request.

Over the years, B.C. has developed a considerable facility in dealing with occupational health issues, and the suitability of their resources and records should be considered for further research into the health effects of welding fume exposure.

Alberta - Department of Manpower and Labour
- Chief Inspector, Boiler & Pressure Vessels

There are 4200 B & PV certified welders recorded at the present time by the Chief Inspector. Certification and recertification is carried out every 18 months, and the above figure consolidates the outcome over a three-year period.

Welding is recognized as a trade in Alberta, and records are kept of all apprentices who graduate to journeymen under provincially established proficiency requirements. In the last six years, the numbers graduating were:

1974 - 251
1976 - 600
1978 - 500
1979 - 518

At the present time there is a total of 2111 apprentices in the three-year program. By year, the distribution is:

3rd Year - 688
2nd Year - 608
1st Year - 815

Thus, for the next three years the number of new welders per year coming onto the labour market with an Alberta certification will range from about 600 to 800. These welders would not have any CWB certification when they leave training school, but they may eventually be included in the welder inventories of employers certified by the CWB. There is thus a good chance the individual welder would appear more than once in records kept by the various certification authorities.

Saskatchewan - Department of Labour

There are 450-500 B & PV certified welders in Saskatchewan at the present time. In recent years, this has fluctuated to as high as 1000, depending upon regional construction programs in hand. Other than CWB certification based on employer requirements, no certification is required for general welding.

Manitoba - Department of Labour and Manpower
- Mechanical Engineering Section

Journeyman welders became recognized tradesmen in 1979. In that year, an attempt was made to take a head count of practising welders in the province. In B & PV welding, 439 persons were licensed; a further 127 trainees failed the test.

In general welding, existing time-served welders numbered about 245 in 1979. Government-sponsored training produced a further 54 in that year. These figures do not include welders employed and accordingly certified by CWB-certified companies.

Ontario - Department of Consumer and Commercial Relations

According to the authorities, no record of B & PV welders has ever been kept. The file access is keyed under welding proficiency type testing and job change testing, with no cross-reference to the individual welder whose name will consequently appear as frequently as he requalifies or changes employment.

The inspectorate has suggested that the required information on B & PV welder population could be retrieved at price, albeit by tedious manual search.

Quebec - Labour and Manpower Department

An estimate of currently certified B & PV welders provided by the Department is 3000 - 3500.

New Brunswick - Department of Labour

Certification tests for 4500 B & PV welders were carried out in 1979. Again, the identification of individual welders taking these tests is not possible without a manual search of the records.

The figure includes retests and higher proficiency tests of already certified welders. The B & PV inspectorate points out that at the present time, B & PV welder migration, particularly from Nova Scotia, would temporarily swell this figure since these transients, although certified in Nova Scotia, would have to be recertified in New Brunswick.

The Department has offered 3000 as an informed estimate of the number of B & PV certified welders employed in the province on a steady basis.

The St. John nuclear project and oil refinery construction has recently attracted B & PV welders from other provinces. The Department of Labour advises that the province has a higher-than-normal ratio of construction/shop welders due to extensive construction programs currently under way.

Nova Scotia - Department of Labour

The B & PV Inspection Branch has supplied the following figures:

	Pressure Pipe	Pressure Plate	Total B & PV Welders
1978	77	6	83
1979 (retests brought forward plus new tests)	144	84	228

Prince Edward Island - Department of Labour

The Chief Boiler Inspector's Office has supplied a figure of 12 B & PV welders currently certified in the province. The Department suggests that this represents about 5 per cent of all persons engaged in welding, brazing and cutting.

Newfoundland - Department of Labour

a) Director of Engineering and Technical Services
b) Program Planning and Review

In 1979, there were 450 B & PV certified welders. Since welding is a recognized trade in Newfoundland, some records have been kept in very recent years of graduates from welding trade schools. Whilst these are not complete, they provide for an estimate of about 500 general welders currently employed and trained in Newfoundland, but this figure does not reflect migration into the province.

TABLE 7

SUMMARY OF ESTIMATES OF BOILER AND PRESSURE VESSEL CERTIFIED WELDERS BY PROVINCE

Province	Estimate from Certifying Authorities
British Columbia	Not available
Alberta	4200
Saskatchewan	450-500
Manitoba	439
Ontario	Not available
New Brunswick	3000
Quebec	3000-3500
Nova Scotia	228
PEI	12
Newfoundland	450

3.3.2 Employers

Our investigations indicate, due to the lack of adequate trade definitions and the high mobility of welders, that the most accurate way of estimating the welding population would be to take a cross-sectional sample of employers and literally count those persons engaged in the various categories of welding activity. This, though costly and time consuming, would eliminate three of the major sources of error which would occur using public employment and manpower statistics and proficiency records, which are: occupational self reporting, alternative trade designation and duplicate certification.

For example a sheet metal fabricator or an auto-body repairman, though employed in welding for a substantial number of hours in the work week, is likely to self report or otherwise be designated on pay rolls, as a sheet metal worker or bodyshop worker.

Membership lists of companies associated with welding related organizations such as the Canadian Welding Bureau, the Welding Institute of Canada or the Pipeline Contractors Association of Canada, could be used for selecting a representative sample of employers for estimating the size of the welding population.

We produced a questionnaire which was sent to a small number of selected employers, Appendix I. Even with telephone follow-up the response was far from adequate. One of the problems may have been that the questionnaire addressed in addition to head counts, issues of hazard monitoring, medical surveillance, and compensation claims. We perceived that the majority of employers interviewed were guarded in their response because of the sensitivity of the health issues involved. Also, the time scale of this study was not long enough to allow employers to make the necessary investigations within their plants.

Apart from the difficulties arising from the understandable caution demonstrated by employers in revealing information on occupational health issues, it was apparent in many cases that no one in the company knew how many employees were actually engaged in welding-related activities (with the frequent exception of B & PV welders).

Whilst the outcome of our search in the employer sector is not adequate for estimating the welding population at risk in Canada, it has identified some procedures used in the industry for evaluating welding manpower resources for production planning purposes.

For example, because of the inability of established sources, including the Canadian Employment and Immigration Commission, to provide reliable data on welding manpower, the Alberta Gas Trunkline Co. commissioned a study by Loram International Ltd. of Calgary. This study addressed the availability of welders qualified to work on pipeline construction. We have not had the opportunity to examine the scope of this document, but Loram International has indicated that Alberta Gas Trunkline may be prepared to release the information if formally requested.

A list of company members of the Pipeline Contractors Association of Canada can be obtained from the Association(11).

Employer organizations would appear to be a most promising source of statistics for persons engaged in welding and related occupations. This is not surprising since a scrutiny of actual shop-flow activity must be more accurate than an inference taken from data records. This method of evaluation would be time consuming and expensive. It would also require the cooperation of a number of employers large enough to make up a representative sample for Canadian industry as a whole.

3.3.3 Labour Organization Membership

Most of the unions questioned were unable to give estimates of the number of member welders. Public service unions, with the exception of the Public Service Alliance of Canada (which bargains primarily along occupational lines) were only able to give estimates based upon employer (government) maintained documents, rather than from their own records. Most of the unions would, by means of shop floor surveys, be able to supply estimates of welders, but depending upon the size and structure of the organization in question, this could prove to be expensive and time consuming.

One union representing workers in the construction trades, stated that it would be unable to identify welders due to the non-specific documentation used in hiring procedures, the range of skills possessed by many of its members (bricklayer-plumber-welders for example), and their traditional mobility. In addition, the wide distribution of welders within a number of separate unions complicates the task even more.

We were unable to find that job history records are maintained by unions for their members. Seniority lists may provide, in specific circumstances, some idea of length of exposure, though seniority for welders currently identified may have been accumulated in non-welding jobs.

We believe that unions can provide, on a plant or industry-wide basis, sample groups of welders for epidemiological studies. In many cases, unions and their members have already been active participants in various occupationally related health studies.

3.3.4 Government and Labour Sources

(i) Statistics Canada Decennial Census

The Decennial National Census Program provides certain pointers for estimating the number of Canadian welders. Ongoing analysis of these data, undertaken by Statistics Canada, generates specific information on region, place of residence, age and sex. The census data are considered to be a reliable source of general occupational distribution statistics and a moderately reliable base for occupational-specific population figures.

The 1971 Census(10) relied on the self-designation of occupation by every third census participant. There are several evident shortcomings with this method for occupational health purposes. No information is presented on length of employment; self-designation is subject to individual interpretation; welders are quite mobile and may be missed from the census in significantly large numbers; and other occupational designations may disguise extensive welding exposure.

The 1971 Census returns were coded using the system of the Canadian Classification and Dictionary of Occupations, 1971, (CCDO)(9), using the four-digit code - in the case of welders, 8335. Identification of the populations in the "37" sub-classifications of welders at the seven-digit level is consequently not possible. Earlier census programs used earlier versions of the CCDO, thus making historical comparisons difficult. The 1981 Census will select only every fifth participant for occupational data collection. This variance in methodology from the 1971 system will further detract from the ability to analyze trends.

(ii) Occupational Employment Survey (OES)

The OES was initiated by Statistics Canada to satisfy a need for a biennial, establishment-based survey to produce estimates of employment by occupation, industry and province. A principal objective was to generate a base for the development of labour market policies and programs, manpower counselling, and educational planning and counselling. The survey includes 80 000 reporting units covering approximately 37 per cent of total paid workers. Response rate was about 87 per cent in 1975 and 1977.

A number of major OES design problems are identified in the document "Analysis of Estimates from the Occupation Employment Survey, 1975 and 1977"(12), prepared by the Research and Analysis Group of the Labour Division, dated September 1979. The methodological aspects of the survey are currently under review by the Business Surveys Methods Division. The "Analysis" concludes that:

> "Overall, given the present data and processing methods in the OES, it is unrealistic to expect this survey to produce occupational employment estimates that are representative of the occupational mix of either the Canadian economy or individual industries."

The OES has consequently been discontinued until solutions can be found for the problems that were documented in the "Analysis".

(iii) Labour Canada

Labour Canada produces a survey entitled Wage Rates, Salaries and Hours of Work to supply regular payroll data using occupational categories to the seven-digit level of the CCDO 1971 system (sub-occupation: types of welding). The data is gathered primarily by mail from selected employers, with only those employing more than 20 people included in the sample. A major weakness is that the survey is not made at all for welders in the construction industry. Researchers estimated a return rate of approximately 45 per cent on survey questionnaires submitted to employers. Because of the limitations in coverage of industry, and the low response rate, numbers for welders derived from this survey would not appear to be very meaningful.

(iv) Manpower and Immigration Canada

The Canadian Occupational Forecasting Program (COFOR)(13) was developed in response to the needs of Canada's manpower and immigration policies. It is designed to aid planning for counselling, training, placement and immigration selection. Its first publication provides forecasts for the period 1974-82 for some 390 out of a target of 500 occupations, and forecasts are made for 69 industries. It is a rather sophisticated combination of computer forecasting models, addressing regional economic imperatives.

The data base used for COFOR is the occupational distribution of the 1971 Census. Forecasts are obtained directly from the econometric simulation program of the Canadian Disaggregated Inter-Departmental Econometric Model (CANDIDE).

Demographic probabilities of death and retirement are used to forecast provincial replacement needs by occupation and these are subsequently aggregated across the provinces to forecast national needs. Occupations are coded at the four-digit level using the CCDO codes.

Because of the failure of the OES, there is no regularly updated data base for industrial employment distribution. Consequently, COFOR relies on the 1971 Census distribution which, as previously noted, may lead to considerable error.

COFOR is designed to project manpower needs. It is inappropriate as a basis for estimation of current occupational populations. The welder population estimates from the 1971 Census, COFOR (1982) and OES (1975, 1977) are given in Table 8 along with an estimate provided by the Welding Institute of Canada (WIC) for 1980.

TABLE 8

VARIOUS ESTIMATES OF CANADIAN WELDING POPULATION

REGION	SOURCE FOR NUMBER OF WELDERS											
	CANADIAN NATIONAL FORECASTING PROGRAM (COFOR)						WIC ESTIMATE 1980	1971 CANADA CENSUS			OCCUPATIONAL EMPLOYMENT SURVEY (OES)	
	DEMAND		Required Increment	Withdrawals (Death)	Net Supplement Requirement 1974-82	Distribution by Province 1982 / %		Men	Women	Total	1975	1977*
	1974	1982										
British Columbia	7600	9275	1675	1950	3625	10.8						
Alberta	5725	8725	3000	1425	4425	10.2						
Saskatchewan	1650	2250	600	425	1025	2.6						
Manitoba	2550	2800	250	600	850	3.3						
Ontario	32425	39950	3525	7425	10950	42.1						
Quebec	18825	20975	2150	4650	6800	24.7						
New Brunswick	1625	1825	200	375	575	2.1						
Nova Scotia	2000	2350	350	525	875	2.7						
Prince Edward Island	150	200	50	50	100	0.2						
Newfoundland	925	1075	150	225	375	1.3						
Canada	73475	85425	11950	17650	29600	100	60000	58535	2790	61325	45470	40540

* Not Published

4. OCCUPATIONAL HEALTH LEGISLATION

There are 12 jurisdictions in Canada with autonomy in the area of occupational health and safety law; 10 provinces, the jurisdiction of Labour Canada and the jurisdiction of the federal government as an employer. The Department of National Defence is a thirteenth entity with apparent autonomy in this area, though some uncertainity exists as to the degree to which the Treasury Board directive is applied within the DND on behalf of civilian employees.

Where occupational health and safety law is documented in this section, we have endeavoured to select those Acts and Regulations which could conceivably have a bearing directly or indirectly upon the occupational health risk experienced by persons exposed to fume generated in welding and allied processes. The exercise therefore has involved a certain amount of interpretation on our part regarding the relevancy of various regulations to the objectives of the study. To undertake an evaluation of the extent of application and effectiveness of enforcement of welding related occupational health legislation would be a study in its own right. However, where possible, we have noted staff complements within the various inspection and enforcement agencies as one indication of the resources available for the coverage of industrial premises. The hazard control effectiveness of the actual criteria used by all the inspectors within all the jurisdictions during onsite evaluation of welding operations is impossible to assess without a great deal of investigation and observation.

The statutes under which the administration of Canada is accomplished are traditionally in a state of dynamic equilibrium. This must influence the situation within the realm of occupational health law; and indeed one trend we see here is towards rationalization. The evolution of the art of industrial hygiene has exposed a need to construct sound scientific principles upon which to build standards for pursuing occupational health risk evaluation and control. As such principles are established, rationalization in the regulatory approach to workplace health problems appears to be accelerating.

Provincial omnibus legislation, such as Quebec's Bill 17 and Ontario's Bill 70, is appearing in an attempt to remove inter-agency confusion in the administration of existing regulations enshrined in many different Acts.

Pressure from labour organizations has had a significant impact on the timing and content of new occupational health legislation. Joint safety and health committees in the workplace, together with requirements for the disclosure of toxic materials information and monitoring results exemplify two features of contemporary occupational health legislation supported vigorously by the trade unions.

Health hazards in the welding environment are legislated for the most part in what may be called an indirect fashion; that is by reference for example to general regulations for ventilation and respirator usage. These regulations enable the adoption of standards for maximum permissible airborne concentrations of toxic substances in the workplace. Safety regulations for welding (e.g. electrocution, eye protection and skin burns) are more prolific, and these can be found in a wide variety of statutes administered by different branches of the governments concerned.

In no jurisdiction were we able to find a regulation or set of regulations specifically addressing the risk associated with exposure to the particular components of welding fume. However, this is not to suggest that general hazard control legislation does not provide means for the enforcement of welding exposure control measures.

Two salient observations of a general nature arise from this range-finding study of occupational health legislation and welding. The first, not exclusively linked to welding as an occupational category, suggests that the degree of administrative overlap between agencies within the same jurisdiction may impede the enforcement of occupational health and safety legislation. The second is that existing regulations do not adequately recognize the nature and varied composition of welding fume and the consequent health effects arising from exposure.

4.1 Federal Jurisdictions

4.1.1 General

The federal jurisdiction in occupational health and safety matters is complex. More than 14 federal departments and agencies administer or have some regulatory role. There are 21 separate Acts and over 100 sets of regulations promulgated with the apparent intent of addressing the question of health and safety risk experienced in the workplace by employed persons.

The federal legislative jurisdiction is assigned by Section 91 of the British North America Act. The legislative hierarchy is shown in Figure 6. Generally, this jurisdiction covers:

(i) Employees of the Crown and of Crown corporations.

(ii) Personnel in the Armed Forces.

(iii) Employees of any employer involved in a business or undertaking that operates between two or more provinces, such as a pipeline, or which operates internationally, such as a ferry service.

(iv) Employees of an employer who operates a business or undertaking which is declared by Parliament to be in the national interest whether or not the business meets other statutory criteria.

(v) Employees of federally chartered banks.

(vi) Employees of an employer who operates a business or undertaking which is not clearly within the provincial sphere of jurisdiction.

Organizations administered under Treasury Board and under Canada Labour Code Part IV are listed in Appendix II.

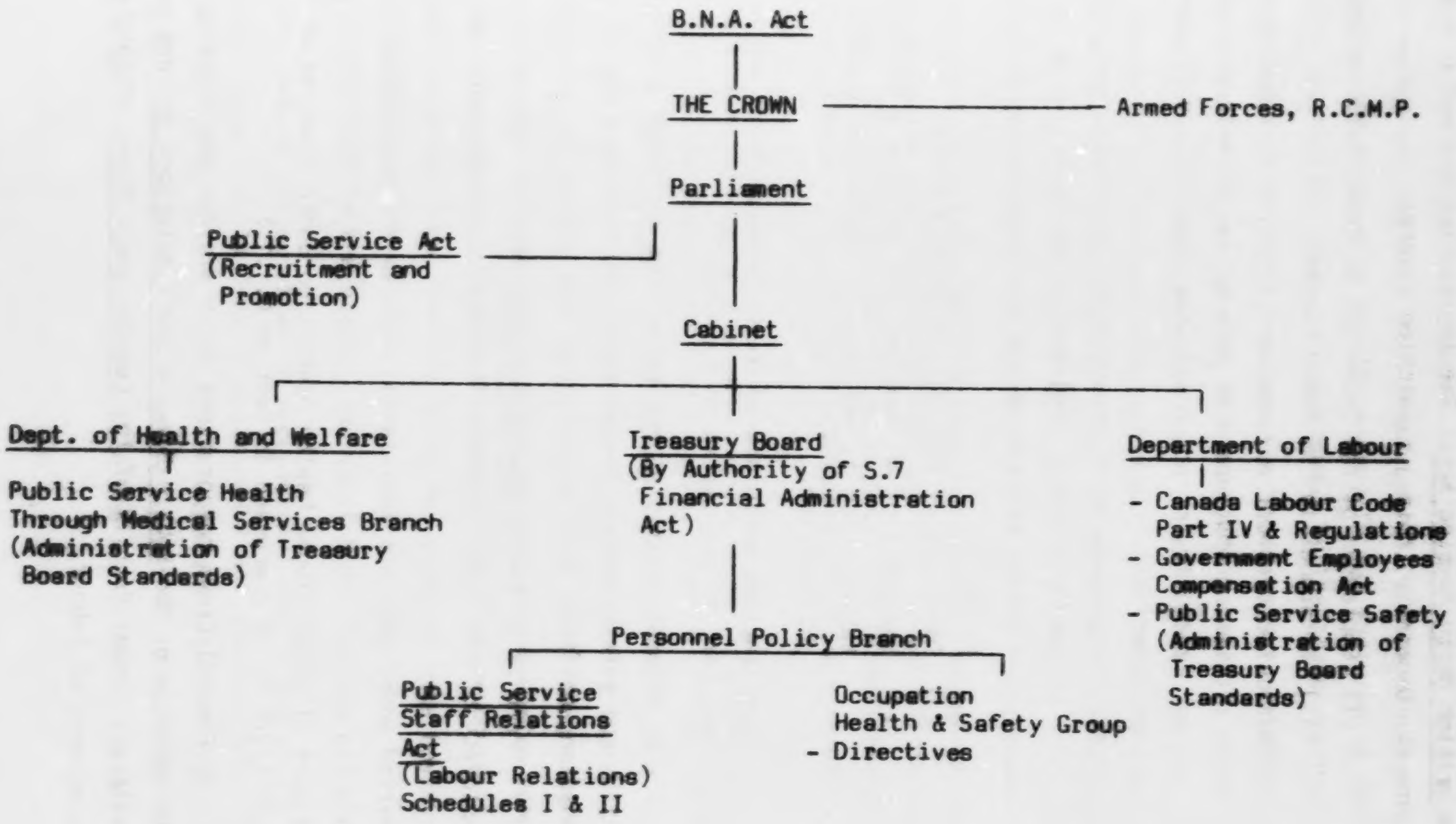
By several unofficial estimates, the workforce covered by federal health and safety legislation accounts for approximately 10 per cent of the Canadian workforce(14,15).

Part IV of the Canada Labour Code does not specifically cover employees of the Crown, R.C.M.P. and military personnel. Also, workers involved with railways, ships or aircraft when moving or under way are covered under separate legislation such as the Aeronautics Act, the Canada Shipping Act and the Railway Act. Employees of the Crown are granted some measure of occupational health protection under a series of Treasury Board Directives to be discussed in Section 4.1.1.3.

Federal Crown corporations which are not specifically included in the Schedule of the Public Service Staff Relations Act are considered to be dealt with under Part IV of the Canada Labour Code, administered by the Department of Labour.

FIGURE 6

SUMMARY OF FEDERAL JURISDICTIONS


B.N.A. Act
THE CROWN
Armed Forces, R.C.M.P.
Parliament
Public Service Act (Recruitment and Promotion)
Cabinet
Dept. of Health and Welfare
Public Service Health Through Medical Services Branch (Administration of Treasury Board Standards)
Treasury Board (By Authority of S.7 Financial Administration Act)
Department of Labour
- Canada Labour Code Part IV & Regulations
- Government Employees Compensation Act
- Public Service Safety (Administration of Treasury Board Standards)
Personnel Policy Branch
Public Service Staff Relations Act (Labour Relations) Schedules I & II
Occupation Health & Safety Group
- Directives

FEDERAL JURISDICTIONS

Principal Occupational Health and Safety Legislation

Legislation	Enforcing Authority
Canada Labour Code Part IV - Safety of Employees (R.S.C. 1970, c.L-1 as amended), and Regulations	Labour Canada
Financial Administration Act (R.S.C. 1970, c.F-10 as amended)	Department of Public Works
Government Property Fire Prevention Standards	Department of Public Works
Employment Health and Safety Policies Standards and Guides for the Public Service of Canada issued by Treasury Board	Labour Canada and Health and Welfare Canada
Government Employees Compensation Act	Labour Canada
Aeronautics Act (R.S.C. 1970, c.A-3 as amended), and Regulations	Transport Canada
Canada Shipping Act (R.S.C. 1970, c.S-9 as amended), and Regulations	Transport Canada
Railway Act and General Orders	Canada Transport Commission

4.1.1.1 Legislation

Canada Labour Code, Part IV, henceforth referred to as Part IV, addresses occupational health and safety issues in much of the federally regulated private sector. There are 21 sets of regulations issued pursuant to Part IV. Six of these regulations address directly or indirectly the potential hazard from welding fumes:

1. Canada Accident Investigation Regulations, SOR/71-583, 76-423.
2. Canada Boiler and Pressure Vessel Regulations, SOR/79-399 as amended.
3. Canada Confined Spaces Regulations, SOR/72-13, 76-423.
4. Canada Dangerous Substances Regulations, SOR/72-66, amended by 76-21 and 76-427.
5. Canada Protective Clothing and Equipment Regulations, SOR/72-108, 74-61, 76-437.
6. Safety and Health Committee Regulations, SOR/78-559.

Section 91 of Part IV enables the appointment of safety officers, authorizing unforewarned inspection of the workplace and records, and the right to take samples. Section 96 gives an officer the power to issue directions for the improvement of safety and health in the workplace environment. Section 97 allows the imposition of a maximum penalty for violations for provisions of the Code and pursuant directions of $5,000 and/or one-year imprisonment.

Section 84 of Part IV provides for self-regulation through labour-management occupational health and safety committees. Section 84.1 outlines the powers and duties of these committees. These include responsibility for education and training of workers in occupational health and safety matters: The "... monitoring of programs, measures and procedures related to the health and safety of employees on a regular basis", and, "... ensuring that adequate records are kept of work accidents, injuries and health hazards; and that monitoring data is obtained therefrom on a regular basis." Administrative details are contained in the Safety and Health Committee Regulations.

Sections 48 and 49 deal with the circumstances under which medical examinations shall be made, and appropriate records maintained.

The Canada Dangerous Substances Regulations contain provisions for the control of airborne contaminants in the workplace, including welding fume. Sections 9, 10, 13, 21 and 28 of the Regulations contain general ventilation requirements including contaminant removal at source "as far as is reasonably practicable", and the exhausting of contaminants in such a way as to prevent dangerous combinations of materials, and to prevent re-entry of contaminants into the workplace environment.

Section 10 references the American Conference of Governmental Industrial Hygienists (ACGIH), which identifies maximum allowable concentrations of airborne substances, amended where appropriate by Canadian authorities. Section 11 specifies conditions under which these standards may, under special circumstances, be exceeded. Section 13 requires sampling to be done by a qualified person as often as is deemed necessary.

Training and education provisions, in addition to those found in Part IV are presented in Sections 15-17 of the Canada Dangerous Substances Regulations. Employees must be informed of potential hazards and instructed in proper use, handling, health protection and emergency procedures. Section 17 requires that records of this training be kept for a minimum of three years.

Section 20 requires the identification and marking of hazardous substances in the manner prescribed by the Transportation of Dangerous Goods Act, the guidelines of the Manufacturing Chemists Association and/or the Hazardous Products Act.

Standards for appropriate testing methods are designated as those set by the ACGIH, the American Society for Testing of Materials, the Dominion Fire Commission, or any other standard recommended by an appropriate federal authority. Test reports must be retained for a minimum of three years and Section 16 describes the type of information required in air sampling reports.

The Canada Protective Clothing and Equipment Regulations, Section 12, requires the use of respiratory equipment which has been approved for its intended use by the United States NIOSH/MSHA* authorities. (There is no Canadian authority for respirator approval and certification equivalent to NIOSH/MSHA). This requirement is likewise covered in Section 14 of the Canada Dangerous Substances Regulations which calls for the use of personal protective equipment "... where it is not reasonably practicable to prevent harmful exposure to dangerous substances ..." and "... will reduce such exposure to a safe level ..."

The Canada Protective Clothing and Equipment Regulations require proper training in the use, care and maintenance of respiratory equipment. The employer is required to keep full records, including the dates and the results of equipment tests and maintenance work.

Labour Canada currently employs approximately 80 labour affairs officers across the country in five Regions, whose primary function is to administer the Canada Labour Code. Labour Canada is also responsible, under the Treasury Board Safety Policy, for administering the Occupational Safety Standards of Treasury Board in the Public Service.

The regional organization of Labour Canada is given in Appendix III.

4.1.1.2 Compensation Claim Procedures

Compensation claims within zones of federal jurisdiction are administered by provincial workers' compensation boards, according to the province in which the claimant is usually employed. This is based on federal-provincial agreement sustained by specific provisions in each province's compensation legislation. Accordingly, provincial compensation boards levy fees against federal employers according to the schedules prevailing in the board's provincial domain.

4.1.1.3 Crown Corporations

The Financial Administration Act defines a Crown corporation as "... a corporation that is ultimately accountable, through a Minister, to the Parliament of Canada for the conduct of its affairs". While the enabling legislation under which Crown corporations operate has been subject to change since 1952, the Financial Administration Act now defines a uniform reporting and control procedure for designated Crown corporations. They are divided into three groups: departmental, agency and proprietorial. Certain Crown corporations such as the Bank of Canada are left un-allocated.

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* National Institute of Occupational Safety and Health,
Mines Safety and Health Administration

For occupational health and safety purposes, all Crown corporations other than the "Departmental" class fall within the jurisdiction of Part IV. "Departmental" Crown corporations are the concern of Treasury Board in health and safety matters. These are identified in Schedule 1 of the Public Service-Staff Relations Act. The allocation of organizations under the Public Service-Staff Relations Act and the Canada Labour Code Part IV is presented in Appendix IV.

4.1.2 Treasury Board

4.1.2.1 Government Employees and Certain Crown Corporations

Section 53 of the British North America Act assigns authority to impose and collect taxes to the Parliament of Canada. The Financial Administration Act enables Parliament to allocate general revenue for governmental business. Fiscal authority relating to the Government's own employment structure is delegated in Section 7 to Treasury Board, a statutory committee of cabinet.

The legislative outcome establishing Treasury Board authority over public service employees is as follows:

(i) The Public Service Act: Defines the Public Service Commission as a recruitment and promotion agency for public service personnel. The Commission reports directly to Parliament and has no formal tie with Treasury Board, other than funding.

(ii) The Public Service Staff Relations Act: Governs labour relations for public service employees. The Treasury Board is identified as the employer for purposes of labour relations and hence occupational health issues. The Public Service

Staff Relations Board concerns itself with the enforcement of employment standards. Procedures relating to these standards (including workplace safety and health) are, at least on a statutory basis, independent of the Canada Labour Code, Part IV.

(iii) Government Employees Compensation Act: This authorizes the processing of compensation claims made by federal public service employees. Adjudication is delegated to the compensation board of the province in which the claimant is usually employed, with special provisions for public service employees in the Northwest Territories, the Yukon and overseas.

The Occupational Health and Safety Group of Treasury Board's Personnel Policy Branch, in consultation with Medical Services Branch of the Department of Health and Welfare has produced the "Handbook of Occupational Health and Safety"(16) from documents contained in Chapter 055 of the Board's Personnel Management Manual.

Health and Welfare, again through Medical Services Branch, is responsible for research, the provision of health data and for the day-to-day administration of the Public Service Health Program. The role of Labour Canada is to "... contribute cooperatively to the Program in a technical and advisory capacity as required."

Responsibility for the administration of Treasury Board Directives lies with each government department. These responsibilities include accident and injury reporting, referrals to Medical Services Branch for medical examination, education and training programs, identification of employees at high risk, and meeting ventilation requirements for hazard control etc.

Labour Canada may conduct workplace health and safety inspections. This service may be complemented where necessary by medical and industrial services provided by Medical Services Branch. Labour Canada's industrial hygiene resources and MSB's medical/occupational health resources appear to have developed a mutually supportive relationship within the complex labyrinth of federal employee health and safety legislation and regulations. A series of field surveys dating back to 1974 have been carried out for welding fume hazard evaluation at CN and CP maintenance workshops across the country by Labour Canada and Health and Welfare Canada (see Section 5.2.3).

Routine medical examinations are conducted in the regional offices of Medical Services Branch, where records are kept. Because of established procedures in the maintenance of other records, such as compensation claims and exposure records, much of this information is not returned on a routine basis to Medical Services Branch.

Treasury Board's Occupational Health and Safety Standards are closely allied with the regulations contained in Part IV of the Canada Labour Code, with minor modifications to meet the special needs of public service work environments. In particular, standards concerning welding environments are similar to those of the Code, discussed earlier in Section 4.1.1.1.

The Periodic Health Evaluation Standard, Treasury Board Standard 3-13, specifically requires Medical Services Branch to undertake employee examinations in designated occupations, according to known data on relative risk. On this basis, welders could be classified in occupation 13(a) described as follows (Ref. 16, pp 142):

"Personnel exposed to toxic materials, harmful dusts, and chemical hazards. (Employees exposed to or handling lead, chromium, ammunition, cyanide, organic solvents, etc.)".

The scope and frequency of examinations of public service workers in this category are to be "... determined by Health and Welfare Canada and communicated directly to departments (in which the employee is employed)."

We are advised by MSB that only medical directives confined to specific individuals have been issued. No health risk to an occupational group of workers has been identified as necessitating the implementation of formal medical surveillance procedures.

4.1.2.2 Statistical Information - Public Service Welders

Labour Canada is able to provide considerable statistical material to Treasury Board covering an estimated 300 000 public service employees. The Board reported 176 work injuries to welders during the fiscal year 1978-1979, 14 of which were compensation cases, 57 involved the granting of injury leave while 105 required first aid only. Seventeen hundred man-days were lost.

A list of public service occupations which may involve welding has been provided by the Public Service Alliance of Canada, Appendix V.

4.1.2.3 Union Representation

Public service welders are concentrated in the "General Trades and Labour" bargaining unit and are represented by the Public Service Alliance of Canada under provisions of the Public Service Staff Relations Act.

Membership by occupation is not recorded by the Alliance. The only occupational statistics available are those held by Treasury Board.

No collection agreement provisions covering workplace surveillance and hazard are on record. This may change as progress is made in the establishment of occupational health and safety committees. While there is, not surprisingly, some disagreement as to which workplace environments require health and safety committees, the Alliance anticipates a fully-operative program in the near future.

The Alliance has recently put in hand a major health and safety program in the training and education field. The program is still in the early stages of development and most training is still carried out through facilities of the Canadian Labour Congress, Provincial Federations of Labour and Local Labour Councils. No welding safety and health program is operative, but plans for the future will recognize the need to address such specific occupational environments.

4.1.3 Department of National Defence

Both Labour Canada and Health and Welfare Canada are involved with occupational issues at bases of the armed services.

The Directorate of Preventive Medicine (DND) confirms that the Treasury Board directive is applied only to civilian employees (who carry out most of the welding tasks anyway). Full-time members of the service are not covered by the directive.

Though there is no occupational health legislation formulated specifically for the DND, Labour Canada has made inspections of DND establishments for the Medical Services Branch of Health and Welfare. It would appear that there is therefore, an instrument within the federal jurisdiction for the occupational health surveillance of those premises of the DND which are occupied by civilian employees, but excludes military personnel.

The Directorate of Preventive Medicine (DND) has expressed concern at the lack of occupational health regulations, recognizing in particular the need to regulate an ever-increasing number of new chemical substances which the department is required to handle. We are advised that at the present time most military bases have an industrial hygiene technician on location, though this person functions without the support of regulated standards for hazard evaluation and control.

4.2 Provincial Jurisdictions

A questionnaire was sent to each provincial government addressing the areas of occupational health legislation and enforcement, administration, records, exposure criteria and welding populations. The questionnaire is found in Appendix VI.

Due to the scope of information requested and the time constraints of the study, the amount of information returned to us was limited. An attempt was made to follow up the mailing by telephone in order to fill in some of the gaps, and as a result we have been able to present an outline of provincial occupational health legislation in the following sections 4.2.1 through 4.2.10.

For each province, we have extracted that legislation containing some reference, direct or indirect, to welder occupational health. This legislation is presented first, together with the designated enforcing authority. We have then elaborated on the regulations to the extent that they address areas of industrial hygiene practice of concern to the welder.

4.2.1 British Columbia

Principal Occupational Health and Safety Legislation

Legislation	Enforcing Authority
Workers' Compensation Act (S.B.C. 1968, C.59 as amended) regulations: (1) Industrial Health and Safety Regulations (B.C. Reg. 587/77) (2) Regulations respecting asbestosis (B.C. Reg. 409/59) (3) Regulations respecting silicosis (B.C. Reg. 411/59) (4) Regulations respecting pneumoconiosis (B.C. Reg. 283/68)	Workers' Compensation Board
Factories Act (S.B.C. 1966, C.14 as amended) regulations: (1) Occupational Environment Regulations (B.C. Reg. 128/24)	Ministry of Labour
Coal Mines Regulation Act (S.B.C. 1969, C.3, as amended)	Ministry of Energy, Mines and Petroleum Resources
Safety Engineering Service Act (S.B.C. 1972, C.56 as amended) Not yet proclaimed	Ministry of Labour
Mines Regulation Act	Ministry of Energy, Mines and Petroleum Resources

While British Columbia's principal health and safety regulations are found in four pieces of legislation, there still remain some 22 Acts and 65 sets of regulations administered by seven ministries and one board which make reference to certain aspects of occupational health and safety. The following legislation addresses welders' fume exposure:

The Factories Act (S.B.C. 1966, C.14 as amended)
The Workers' Compensation Act (S.B.C 1968, C.59 as amended)
The Coal Mines Regulation Act (S.B.C. 1969, C.3 as amended)
The Mines Regulation Act (S.B.C. 1967, C.25 as amended)

The Factories Act's Occupational and Environmental Regulations (B.C. Reg. 128/74) and Workers' Compensation Act's Industrial Health and Safety Regulations (B.C. Reg. 585/77) delineate details of the law.

There is considerable overlap between the powers and jurisdiction of the Workers' Compensation Act and The Factories Act, particularly in the area of ventilation requirements.

Both Acts cover non-mining industrial operations, and both have provisions for the appointment of inspectors with full authority to enter and inspect. (Factories Act section 12, W.C.A. section 60(3) and (9).)

Enforcement under the W.C.A. is covered in sections 61, 62 and 63, and allows for certain penalties, including additional premiums over and above the normal assessments made by the Board. A maximum of $16,242.78 is quoted. Where an officer of the Board considers a situation to be dangerous, a complete or partial work stoppage can be ordered until he feels the unsafe condition has been rectified. The Factories Act provides for a maximum fine, in the event of continued violation, of 10 dollars per day.

The maximum allowable concentrations of contaminants are specified in Appendix 'A' and 'B' of the W.C.A. Regulation 587/77, and are identical to those of the American Conference of Governmental Industrial Hygienists.

Section 26 of The Factories Act requires "proper" ventilation which may be determined at the discretion of the inspector. Hoods are required when dusts, fumes or gases may be injurious to health. Regulation 128/74, section 7.001, requires the submission of new facility designs. These will be evaluated along the guidelines set out in the ACGIH publication "Industrial Ventilation--A Manual of Recommended Practice". Section 9.002 prohibits the recirculation of exhaust air, and section 11.001 lists operations requiring exhaust ventilation.

Regulations under the W.C.A. (B.C. Reg. 587/77), sections 17.03 and 17.05, require the installation of local exhausts where welding, burning, cutting and allied operations create contaminant levels in excess of prescribed limits. Sections 13.37 to 13.39 cover general ventilation requirements, calling for the use of "Industrial Ventilation--A Manual of Recommended Practice" as a guide. Other requirements include the mandatory supply, on request, of drawings and specifications for ventilation systems, the control of contaminants at their source with effective local exhaust systems, adequate make-up air supply requirements, changes in work practices requiring additional ventilation, and the proper discharging from and servicing of air cleaning equipment.

Respirators are permitted by section 17.29 of Regulations 587/77, only where welding or burning operations are of a short duration, or in emergencies, or where the installation of appropriate ventilation is not practicable. In any event, such respiratory protection equipment must comply with the detailed standards set out in Appendix 'C' of the Regulations, which follow National Institute of Occupational Safety and Health (NIOSH) recommendations.

Section 78 of these Regulations requires detailed medical examinations and biological monitoring of workers exposed to certain contaminants. Maximum permissible body burdens are stated. Records of these examinations are to be kept in the custody and control of the occupational physician on a confidential basis. The release of this information, other than to the Board, requires the employees' consent. Occupational diseases must be reported to the Board. Only those welders exposed to lead dust or fume at or above 50 per cent of the Threshold Limit Value, mercury at or above 50 per cent of the TLV, dust containing 1 per cent or more of free silica, dust containing asbestos fibre levels at or above 50 per cent of the TLV, or other harmful conditions (in the Board's opinion) require regular medical and biological examination.

Air sampling may be performed by an inspector or, at his request, under either section 12 of the Factories Act, or section 60 of the W.C.A.

In underground operations, reporting of ventilation flow rates is required by section 40.11 of Regulations 587/77.

Health and safety instruction is the duty of all employers of 20 or more people. Section 4 of the W.C.A. Regulation 587/77 sets out a required industrial health and safety program. This covers the proper handling of and safety procedures required in the use of harmful substances, and the use of respiratory protection equipment.

British Columbia maintains a staff of about 63 Accident Prevention Officers and 22 Industrial Hygiene Officers, who perform all workplace inspections with the exception of federal establishments and mines. The Board supplies both advisory services and education and training seminars.

Both the Mines Regulations Act and the Coal Mines Regulations Act deal with welding operations indirectly by banning the activity in underground operations unless special permission is granted and specified procedures are followed. (Rules 110 and 127 respectively.)

4.2.2 Alberta

Principal Occupational Health and Safety Legislation

Legislation	Enforcing Authority
Occupational Health and Safety Act (S.A. 1976, C.40) Regulations:	Department of Labour
(1) General Accident Prevention Regulations (Alta. Reg. 267/76)	
(2) Designation of Occupations Regulations (Alta. Reg. 288/76)	
Public Health Act (R.S.A. 1970, C.294, as amended) Regulations:	Department of Social Services and Community Health
(1) Provincial Board of Health regulations respecting the protection of persons from fibrosis of the lungs. (Alta. Reg. 265/58)	
(2) Provincial Board of Health regulations respecting the notification of industrial disease. (Alta. Reg. 62/70)	
(3) Provincial Board of Health regulations respecting the protection of workers from the hazards of exposure to lead and lead compounds. (Alta. Reg. 3/72)	
(4) Provincial Board of Health Regulations respecting occupational health. (Alta. Reg. 298/72 amended by 3/73)	
Coal Mine Safety Act (S.A. 1974, C.18) Regulations:	Energy Resources Conservation Board
Coal Mines Safety Regulations (Alta. Reg. 335/75)	
Workers' Compensation Act (S.A. 1973, C.87 as amended) Regulations:	Workers' Compensation Board
General Regulations (Alta. Reg. 362/73)	

Out of Alberta's 21 Acts, 70 sets of regulations, five administering departments and three administering boards concerned with occupational health and safety, three pieces of legislation can be extracted for an examination of Alberta's control of welding fume exposure:

1. The Occupational Health and Safety Act (S.A. 1976, C.40) and its regulations 267/76 and 288/76.
2. The Public Health Act (R.S.A. 1970, C.294 as amended) and its regulations 265/58, 62/70, 3/72 and 298/72 amended by 3/73.
3. The Workers' Compensation Act (S.A. 1973, C.87 as amended) and its General Regulations 362/73.

There is a great deal of overlapping of jurisdiction in the areas of inspection and enforcement of The Occupational Health and Safety Act and its regulations and those of The Public Health Act and its regulations. Both provide for independent inspectors with full powers to investigate and inspect workplace premises (P.B. of P.H.* reg. 298/72, sections 20-3-1, O.H.S.A. section 6), and both provide enforceable directives. (P.B. of P.H. reg. 298/72 sections 20-7-2 through 20-10-1; O.H.S.A., sections 7-10).

The Occupational Health and Safety Act provides for penalties ranging to a maximum of $15,000 and 12 months in jail for persistent non-compliance, while the Provincial Board of Public Health regulations stipulate a minimum $1,000 fine for continued violation. Provision is made for litigational pursuit of an offender.

For maximum allowable airborne concentrations of workplace contaminants the TLV's documented by the American Conference of Governmental Industrial Hygienists are invoked. (General Accident Prevention Regulations 267/76, section 1.5; Provincial Board of Public Health Regulations, section 20-4-4).

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* Provincial Board of Public Health

Extensive ventilation requirements are found in sections 79, 82, 105 and 106 of The General Accident Prevention Regulations 267/76. These provide for the following:

(a) An employer whose operations produce or disseminate gases, vapours, smokes, fumes, mists or dusts which can or may accumulate in hazardous concentrations in work areas, shall install a ventilation system of a capacity sufficient under normal operating conditions to maintain the concentration of the contaminants in the atmosphere of work areas below the Threshold Limit Values established by the American Conference of Governmental Industrial Hygienists and below the lower flammable limit (section 79).

(b) Wherever possible, contaminants are to be controlled at their source (section 82).

(c) Where welding operations take place in a confined space or where alloys are being welded, without personal respiratory protection, local exhausts are to be installed with a minimum face velocity (section 105).

(d) In welding shops, general ventilation must be installed providing a minimum of 2000 cfm per arc unit (section 106).

Requirements for air sampling and testing are stated only for confined spaces or when welding in mines (sampling for methane only), (Coal Mines Safety Regulations 333/75 as amended by Alta. Reg. 354/77).

Respiratory protection is covered in sections 62 - 69 of The General Accident Prevention Regulations (Alta. Reg. 267/76). These place the onus on the employer to ensure the proper selection, maintenance, and use of respirators, and to instruct workers on the correct use of all personal protection equipment.

Routine medical examinations and biological samples are required only in the case of designated hazardous occupations (OHSA, sections 15-19). Provincial Board of Health Regulations 375/71 and 3/72 require regular medical examinations for workers exposed to materials implicated in pulmonary fibrosis, and for lead workers. Lead workers are required to regularly undergo biological monitoring. Records in both cases are required to be maintained by the employer. In addition, the Provincial Board of Health Regulations 62/70 require physicians to report cases of specified industrial diseases on a prescribed form which identifies the occupation of the affected worker.

Statistical work and data exchange is authorized under sections 21 and 23 of The Occupational Health and Safety Act. Education and training provisions are made under the same Act in sections 21, 31(13) and 31(25) including the possible contracting out of training programs involving first aid and emergency training, and the training of workers in hazardous occupations.

4.2.3 Saskatchewan

Principal Occupational Health and Safety Legislation

Legislation	Enforcing Authority
Occupational Health and Safety Act 1977 (S.S. 1976-77, C.53) Regulations: (1) Accident Prevention Regulations (Sask. Reg. 282/69 amended by 218/72, 197/73 and 115/74) (2) Asbestos Regulations (Sask. Reg. 58/75) (3) Mines Regulation (Sask. Reg. 284/78) (4) Regulations respecting the prevention of accidents in garages, automobile service stations, and motor vehicle repair shops. (Sask. Gazette, Sept. 5/47 amended by Sask. Gazette, Apr. 24/48.)	Department of Labour
Workers' Compensation Act, 1974 (S.S. 1973-74, C.127 as amended)	Workers' Compensation Board
Boiler and Pressure Vessel Act, 1977 (S.S. 1976-77, C.8) Regulations: Regulations respecting the welding of boilers, pressure vessels and pressure piping. (Sask. Reg. 61/78 amended by 16/79)	Department of Labour

The principal piece of occupational health legislation in Saskatchewan is the Occupational Health and Safety Act (S.S. 1976-77, C.53) and its regulations: Accident Prevention Regulations (Sask. Reg. 282/69 amended by 218/72, 1972-73 and 115/74) and Asbestos Regulations (Sask. Reg. 58/75), and Mines Regulations (Sask. Reg. 284/78).

The Act applies to all employers and employees in the province including self-employed persons, with the exception of those operating in the federal jurisdiction.

Section 17 establishes inspectors with full investigational powers and the power to issue notices of contravention (section 18), which must be posted along with a schedule of remedial measures to be taken within seven days of the contravention. The inspector is also authorized to close the workplace where it is considered necessary, under the regulations.

Section 33 allows for penalties in the case of non-compliance with the Act's provisions to a maximum of $5,000 ($500 per day) followed by a maximum of $10,000 ($1,000 per day) for a second or subsequent violation. A penalty of up to $500 per day may be issued for obstructing the work of the inspector.

The Accident Prevention Regulations (sections 16.00 to 16.16) require adequate ventilation, and make reference to ACGIH ventilation guidelines. Contaminants are required to be removed at the source wherever possible. Where this is not possible, adequate general ventilation is required with a makeup air supply sufficient to replace exhaust, to minimize contaminant dispersion and to restrict the proportion recirculated.

Respiratory protection apparatus must be appropriately selected for its use (section 22.28, 22.32) and the employer must ensure that employees have been properly instructed in its correct use (section 22.24).

Section 16.28 of the Accident Prevention Regulations requires adequate ventilation for welding operations, including the use of separate exhaust systems, or respiratory protection where this is not possible.

Section 29 of the Act allows the Chief Medical Officer to make examinations of workers with their consent. On the basis of this examination, a worker may be ordered removed from a particular work station (section 30).

The Occupational Safety and Health Division is charged with responsibility for the promotion and conduct of educational programs and research, and may supply financial grants for these purposes (section 8 of the Act). It is also the Division's responsibility to prepare and maintain morbidity and accident statistics relating to workers, either independently or in conjunction with the Workers' Compensation Board.

Saskatchewan has an extensive extra statutory occupational health and safety promotion program. TLV's of the ACGIH are used in evaluating workplace exposure to hazardous agents. Saskatchewan employs 24 inspectors responsible for mines and all commercial and industrial establishments.

4.2.4 Manitoba

Principal Occupational Health and Safety Legislation

Legislation	Enforcing Authority
Workplace Safety and Health Act (S.M. 1976, C.63 as amended) Regulations: (1) Regulations covering required protection against injury of workers in workplaces, and respecting the protection of other persons from risk to safety or health, arising out of activities in the workplace. (Man. Reg. 204/77) (2) Regulations respecting the protection of persons engaged in any industrial process, particularly processes involving the use or manufacture of lead or benzene. (Man. Reg. 208/77) (3) Regulations respecting workers employed in certain industries in which pulmonary fibrosis (including silicosis) may be contracted. (Man. Reg. 209/77) (4) Regulations respecting the composition and functioning of workplace safety and health committees, and respecting certain procedures in accordance with the Act. (Man. Reg. 158/77 amended by 203/77) - A code of practice for workplace safety and health committees, which is a guide to their organization, function and procedures: see SS 18-21 of the Act and S. 8(1) of Manitoba Regulation 158/77, published in the Manitoba Gazette of September 10, 1977, pages 1186-1192.	Department of Labour and Manpower
Workers' Compensation Act (R.S.M. 1970, C.W. 200 as amended)	Workers' Compensation Board

Legislation	Enforcing Authority
Steam and Pressure Plants Act (R.S.M. 1970, C.S. 210) Regulations: (1) Standards of construction, installation, and maintenance of steam and pressure plants, and fixing of fees for inspection and Certificates of Inspection Regulations. (Manitoba Regulation 101/72 as amended by Reg. 24/74.)	Department of Labour and Manpower

Occupational health and safety legislation in Manitoba is administered by five different departments and two boards through the provisions of 16 Acts of the Legislature and 38 sets of regulations. Legislation which concerns itself with the protection of workers from welding fume exposure is confined to the Workplace Safety and Health Act, (S.M. 1976, C.63 as amended) and four sets of regulations to that Act.

Every employer, worker and self-employed person in the province is addressed in the Workplace Safety and Health Act. Inspectors appointed under the Act have wide powers of inspection, examination of premises, measurements and sample taking (sections 14, 24) and enforcement of orders (Improvement Orders section 26, 36) up to and including permanent closure of an unsafe operation.

Ventilation requirements are specified in Manitoba Regulations 204/77 in section 15: "Every workplace shall be adequately ventilated; and, where the air within the working area is contaminated to the extent that it constitutes a safety or health hazard, suitable means shall be provided to protect the safety and health of the workers."

No maximum permissible concentrations of contaminant in air are specified in the Act or its regulations, although The Mines Act, in section 4.22 does require that the TLV Guidelines set by the ACGIH be met. However, in practice, provincial inspectors appointed under the Workplace Safety and Health Act do use the ACGIH TLV's as guidelines for the determination of safe contaminant levels.

Medical examinations are not routinely required in Manitoba, but under section 49 of the Act, the Chief Medical Officer may require (with the workers' consent) that a medical examination be carried out. In addition, workers using lead may be required by the Minister of Labour to submit to medical examinations at the employer's expense (Manitoba Regulation 208/77, Section 3(1). Workers in foundries or other designated types of workplace are required to submit to annual medicals in order to obtain and renew their licences to work in such designated workplaces (Manitoba Regulation 209/77).

Responsibility for instruction on particular workplace hazards falls upon the employer under section 14(1) of the Act. However, more general health and safety training is made the responsibility of the Safety and Health Committees with the assistance of the staff of the Workplace Safety and Health Divisions. (See Code of Practice for workplace safety and health committees, sections 2 (c) (iii), 31, and 35.)

Lead-containing materials used in the workplace are the only materials requiring specified markings. (Man. Reg. 208/77)

4.2.5 Ontario

Principal Occupational Health and Safety Legislation

Legislation	Enforcing Authority
Occupational Health and Safety Act (S.O. 1978, C.83) Regulations: (1) Regulations for Industrial Establishments (Ont. Reg. 658/79 as amended by Ont. Reg. 844/79) (2) Regulations for Construction Projects (Ont. Reg. 659/79 as amended by Ont. Reg. 845/70) (3) Regulations for Mines and Mining Plants (Ont. Reg. 650/79)	Ministry of Labour
Boiler and Pressure Vessels Act (R.S.O. 1970 C.47 as amended) Regulations: General Regulations (R.R.O. 1970. Reg. 75 last amended by O.R. 713/75)	Minister of Consumer and Commercial Relations
Workmen's Compensation Act (R.S.O. 1970, C.505 as amended)	Workmen's Compensation Board

Up until the late 1970's, Ontario dealt with occupational health and safety legislation in 26 Acts administered by eight Ministries and one Board. There were in excess of 45 sets of regulations. The province has recently undertaken extensive legislation revision. and has considerably reduced the complexity of its health and safety legislation. The majority of these provisions are contained in the Occupational Health and Safety Act (S.O. 1978, C.83) and its Regulations for Industrial Establishments (Ont. Reg. 658/79 as amended by O.R. 847/79), Regulations for Construction Projects (O.R. 659/78 as amended by O.R. 845/79) and Regulations for Mines and Mining Plants (O.R. 660/79).

The Occupational Health and Safety Act specifically excludes from its coverage domestic workers, farm workers, teachers or university teachers or teaching assistants. The number of welders in these categories is likely to be small, but may include, for example, welding teachers or instructors in colleges.

Section 5 provides for the appointment of inspectors, and sections 20-28 outline the extensive powers and duties of the inspector. Violation of the Act or of an inspector's directive could lead to a maximum fine of $25,000 and a 12-month jail sentence. Maximum permissible concentrations of airborne contaminants will be as prescribed (section 15(f)). Ontario has embarked upon a program of standards setting. Proposed standards are gazetted and public submissions are invited prior to final adoption. Table 9 shows current intentions with regard to standards setting together with a commentary on procedural methods used. No specific reference is made to welding fume as a heterogeneous emission, but metallic components such as chromium, cadmium and iron oxide are listed. At present, ACGIH TLV's are used, where appropriate, as enforceable guidelines.

Section 21 of the Occupational Health and Safety Act requires that toxic information on new substances being introduced to the workplace must be submitted at the Director's request to the Ministry of Labour.

Section 18 of the Act may require that drawings and plans be submitted to Ministry engineers for approval. Section 7(2) of the Regulations for Industrial Establishments requires "where so prescribed" the submission of details of ventilation systems to be installed in new establishments as well as "...details of equipment, machinery or devices to be used in the processing of toxic or designated substances." Sections 131 and 132 contain general ventilation requirements including a supply of make-up air free from contaninants. Sections 73 and 74 of the Act deal with the ventilation requirements of confined spaces.

Sections 235-237 of the Regulations for Construction Projects deal with work in underground situations. Respiratory equipment is to be used where mechanical ventilation is not practicable. The air must be checked for contaminant levels at regular intervals. The protection efficiency of respiratory equipment must be similarly checked.

Section 83 of the Industrial Establishments Regulations requires that workers using respiratory equipment are fully instructed in its proper care and use. Section 15(i) of the Act further requires the provision of written instructions to an employee who is working with hazardous materials. Section 15(c) requires the maintenance of records on the use, handling and disposal of hazardous materials, and subsection (d) requires that any workplace exposure records that may be held be made available to the employee concerned at his request.

Ontario has put in hand extensive measures for the promotion of public awareness in occupational health and safety. Regular publications are made available together with access to excellent library facilities. In addition, the province has made a substantial contribution in the area of labour education in occupational health and safety.

TABLE 9

REGULATED SUBSTANCES; ONTARIO MINISTRY OF LABOUR

In the summer of 1978, the Ontario Ministry of Labour published "Notice of Intent to Regulate" seven workplace hazards. These seven hazards and the proposed 8-hour standard for each were:

Noise	85 dB(A)
Lead	.15 mg/m^3
Mercury	.05 mg/m^3
Vinyl Chloride	5 ppm
Silica	.1 mg/m^3
Isocyanates	.002 ppm
Asbestos: Chrysotile	2 f/cc (>5 microns in length)
Amosite	.2 f/cc
Crocidolite	.2 f/cc

The Ministry of Labour asked that interested unions, workers, businesses and the public submit comments on the proposals. Further comments or meetings may be sought. All the comments are then reviewed internally and the standard published in its final form. So far the standards proposed above have not been adopted by the Province of Ontario. They are still being reviewed.

During the Labour Estimates in the Ontario Legislation in December 1979, the Ministry tabled their priority list for the investigation and possible regulation of additional toxic substances.

The list of substances for future action are:

1979-80

Arsenic
Chromium
Benzene
Acrylonitrile
Amines
Diesel Emissions
Toxic Substance Labelling
Carcinogens Policy
Cadmium

1980-81

Tetrachloroethylene
Styrene
Trichloroethylene
Nickel
Organophosphorous Pesticides
Hazardous Waste Handling

1981-82

Epoxy Resins
Chlorinated Hydrocarbons
Fire Retardants
Organotin Compounds

1982-83

Nitro Compounds
Iron Oxide
Ketones
Hydrogen Fluoride
Wood Dust

4.2.6 Quebec

Principal Legislation in Occupational Health and Safety

Legislation	Enforcing Authority
Environment Quality Act (S.Q. 1972, C.49 as amended) Regulations:	Department of the Environment
(1) Concerning Hot Mix Asphalt Plants (O.C. 2876-74)	
(2) Concerning Industrial Establishments (O.C. 479-44 amended by 474-48, 406-49 and 718-63)	
(3) Designed to ensure sanitary conditions in industrial camps and others. (O.C. 958-50 amended by 881-54, 635-61, 1939-63 and 687-78)	
(4) Respecting the quality of the working environment (O.C. 3169/79)	
Industrial and Commercial Establishments Act (R.S.Q. 1964, C.150 as amended) Regulations:	
(1) Construction Safety Code (O.C. 1576-74 amended by 4790-75, 236-77, 3284-77, 594-78 and 855-78)	Office de la Construction du Québec
(2) Concerning Industrial and Commercial Establishments (O.C. 3787-72 amended by 1576-74, 1958-76, 3326-76 and 594-78)	Department of Labour and Manpower
(3) Respecting Safety and health foundry works (O.C. 3454-73 amended by 594-78)	
Pipe Mechanics Act (R.S.Q. 1964, C.154 as amended)	Department of Labour and Manpower

Legislation	Enforcing Authority
Pressure Vessels Act (R.S.Q. 1964, C.156 as amended)	Department of Labour and Manpower
*This Act has been replaced by an Act respecting pressure vessels: Bill 61 (1979) which is not yet promulgated (as of spring 1980)	
Mining Act (S.Q. 1965, C.34 as amended) Regulations: (1) Respecting Safety and Protection of workmen in mines and quarries (O.C. 4839-71 amended by 1193-72, 2734-74, 2583-75, 2308-77 and 2532-78)	Department of Natural Resources
Workmen's Compensation Board (R.S.Q. 1964, C.159 as amended) Regulations: (1) Concerning the institution of the Advisory Committee on industrial accidents (O.C. 4132-70 amended by 4788-70) (2) No. 33 (1978) concerning first-aid services (O.C. 856-78)	Workmen's Compensation Commission

Quebec Bill 17 (1979) will enable rationalization of the many regulations concerning health and safety in the working environment which are at present contained in existing statutes such as the Industrial and Commercial Establishments Act, the Pressure Vessel Act, the Workmen's Compensation Act and the Construction Industry Labour Relations Act. In certain cases, existing statutes are repealed completely in favour of Bill 17.

The only references to welders in existing legislation are concerned with flammable atmosphere precautions (Industrial and Commercial Establishments Act).

Bill 17, an Act Respecting Occupational Health and Safety, excludes employees of the federal and provincial governments, and employees of Crown corporations. At present, the Department of the Environment, Directorate of Industrial Hygiene administers the new regulations. In the near future, responsibility will be transferred to the newly-formed Commission de la Santé et de la sécurité au travail.

No specific reference to health hazards in the welding environment is made in the regulations of Bill 17. Addressing health and safety in the general workplace, the provisions are extensive; those sections dealing with toxic materials, ventilation requirements, personal protective equipment etc. will clearly affect the welder's working environment.

The intent of the Bill is to "... provide mechanisms for the participation of workers and employers in the elimination of the causes of occupational accidents and occupational diseases."

The Commission de la Santé et de la sécurité au travail is established under Bill 70 to replace the Commission des accidents du travail du Québec.

Workplace inspections will be made by qualified engineers and technicians, who will also be empowered to order changes and improvements according to provincial standards. The same personnel will monitor employer compliance with directives issued.

About 30 persons are currently employed in industrial health inspections.

No occupational health education programs are currently in force.

Plant monitoring results are made available to labour unions and workers.

Provincial employees' occupational health affairs are handled by a central committee called the Comité d'hygiène et sécurité au travail.

Maximum permissible exposure levels in the workplace are adopted from those of the ACGIH.

4.2.7 New Brunswick

Principal Legislation in Occupational Health and Safety

Legislation	Enforcing Authority
Occupational Safety Act (SNB 1976, C,0-0.1 as amended) Regulations: (1) Regulations establishing an Industrial Safety Council (N.B. Reg. 76-72, amended by 77-69 and 79-5) (2) Occupational Safety Code (N.B. Reg. 77-1 amended by 77-19, 77-92, 78-53 and 78-72)	Department of Labour and Manpower
Workmen's Compensation Act (R.S.N.B. 1973, C.W-13 as amended) Regulations: (1) Regulations under the Act (N.B. Reg. 67-13 amended by 69-121, 76-140 and 79-30)	Workmen's Compensation Board
Boiler and Pressure Vessel Act (S.N.B. 1976, C.B.-7.1) Regulations: The New Brunswick Boiler Pressure Vessel Code 1976 (N.B. Reg. 76-84 amended by 76-100)	Department of Labour and Manpower

Seven New Brunswick Departments and one Board enforce the province's 14 Acts and 25 sets of regulations. Only the Occupational Safety Act (S.N.B. 1976 C.0.0.1 as amended) and regulations 76-72 amended by 77-69 and 79-5 pertaining to establishing an Industrial Safety Council, and the Occupational Safety Code (N.B. Regs. 77-1, amended by 77-19, 77-92, 78-53 and 78-72) have specific provisions in connection with welding fume exposure.

The Occupational Safety Act, applying to all employers of one or more people (with a few exceptions), is enforced by Occupational Health and Safety officers appointed pursuant to provisions of Section 4 of the Act. The officers have full power to enter, inspect and take samples from workplaces. Where they find violations, they may take appropriate measures to protect the health of workers, up to and including the ordering of full work stoppage. When such orders are ignored, fines of between $100 and $5,000 may be levied and default on these fines could result in imprisonment in accordance with provisions of the Summary Convictions Act.

Section 8(4) of the Occupational Safety Code states:

> "The employer shall ensure that where air in working areas may be contaminated, which may constitute a hazard to the health or safety of the employees, the concentration of such substances shall not exceed the Threshold Limit Values recommended by the American Conference of Governmental Industrial Hygienists in its publication entitled, 'Threshold Limit Values for Chemical Substances and Physical Agents in the Workroom Environment...'"

(Presumably this section allows for annual revisions of the reference TLV's as per ACGIH annual updates.)

The Regulations section 8(3), require the removal of air contaminants at source by the use of hoods, ducts, etc; section 27(27) requires that "Adequate ventilation shall be provided where welding and cutting is taking place."

Sections 9 and 10 of the Regulations address requirements for approved respirators, stipulating that the care and correct type selection of respirators is the employer's responsibility. Specifically, in confined spaces (section 1013) or where the welding or heating process produces toxic fumes (section 9(1)(c)), proper respiratory protection must be worn.

The Regulations establishing an Industrial Safety Council put the responsibility for the training and education of workers in the area of safety and health on the Council (section 7). Research and compilation of accident and industrial disease statistics is deemed necessary to help set priorities in the development of educational programs.

There are currently 11 safety officers responsible for all provincial workplaces, except mines which are covered by four additional officers. The new Occupational Health Division of the Department of Labour, planned to begin operation in 1980, will provide advice on occupational health matters to the officers. Occupational health hazard control advice will also be provided by the Division.

At present, the Occupational Health and Safety Council puts on a short course for workers employed in welding activity.

4.2.8 Nova Scotia

Principal Legislation in Occupational Health and Safety

Legislation	Enforcing Authority
Health Act (R.S.N.S. 1967, C.247 as amended) Regulations: Regulations respecting industrial and Construction Camps Occupational Health Regulations (Regs. of N.S. 1977, p. 269)	Department of Health
Industrial Safety Act (R.S.N.S. 1967, C.141 as amended) Regulations: Industrial Safety Regulations (Amended by N.S. Reg. 135/77)	Department of Labour
Workmen's Compensation Act (R.S.N.S. 1967, C.343 as amended) Regulations: Workmen's Compensation Board Regs. (S.N.S. 1969, p. 609)	Workmen's Compensation Board
Coal Mines Regulations Act (R.S.N.S. 1967 C.36 as amended) Regulations: Occupational Health Regulations (N.S. Reg. 137/77)	Department of Mines
Metalliferous Mines and Quarries Regulation Act (S.N.S. 1968, p. 390) Regulations: Occupational Health Regulations (N.S. Reg. 139/77)	Department of Mines

Legislation	Enforcing Authority
Mineral Resources Act (S.N.S. 1975 C.12) Regulations: Occupational Health Regulations (N.S. Reg. 138/77)	Department of Mines
Construction Safety Act (R.S.N.S. 1967, C.52 as amended) Regulations: Construction Safety Regulations (Amended Regs of N.S. 1974 p. 34 and N.S. Reg. 136/77)	Department of Labour

Nova Scotia's occupational health legislation is disseminated among 21 Acts and 35 sets of regulations and is administered by seven different governmental departments and two boards. The bulk of legislation addressing welding fume exposure is found in three Acts:

(1) The Public Health Act (R.S.N.C. 1967, C.247 as amended)
(2) The Industrial Safety Act (R.S.N.S. 1967, C.141 as amended)
(3) The Workmen's Compensation Act (R.S.N.S. 1967, C.343 as amended)

Welders working in various types of mining operations are covered by separate legislation. All three of the above Acts provide for inspectors with powers to enter premises, make orders, and enforce them. (PHA Occupational Health Regulations, section 3.7 and 8, were also adopted as regulations under The Industrial Safety Act with the Minister of Labour responsible for their administration.)

In practice, the two occupational hygienists on the Department of Health staff provide advice on technical matters to inspectors from the Departments of Labour and Mines and the Workmen's Compensation Board. Inspectors from other departments may take Department of Health recommendations and translate them into enforceable directions according to statutory provisions. The Industrial Safety Act can ultimately enforce an unheeded directive by summary conviction, a maximum fine of $100 or in the case of default of payment a maximum jail term of 30 days.

A second transgression is liable for a maximum fine of $500 and, where payment of this fine is not made, a prison term of 90 days is provided for.

Under Section 8 of the Public Health Act's Occupational Health Regulations, if an inspector's compliance order is not followed, the Attorney General may be requested to institute court action against the offender.

Section 4(1) of the Occupational Health Regulations invokes ACGIH TLV's for maximum permissible air concentrations. As these are updated, so are the regulations under the Industrial Safety Act, Construction Safety Act and the various mines safety Acts.

Section 18 of the Industrial Safety Act provides authority to request drawings, floor plans and systems layouts for new plants or extensions. Regulation 135/77, section 265, states:

> "Local exhaust and ventilation shall be provided where welding or cutting is being carried out in confined spaces, to prevent the accumulation of toxic gases or metal fumes or possible oxygen deficiency."

Section 19 of the Regulations provides for General Ventilation levels which are reasonably free of contaminants and which provide adequate fresh air make-up.

Contaminant concentration levels in workroom air must be maintained below the TLV's set by the American Conference of Governmental Industrial Hygienists. This requirement is laid down under section 4(1) of the Occupational Health Regulations of the Public Health Act, and also takes effect under the Industrial Safety Act.

Nova Scotia Regulations 135/77 in section 177(d) require the supply and use of "suitable breathing apparatus manufactured for the purpose of protecting persons from exposure to hazardous contaminants."

Section 10 of the Public Health Act gives the Director the power to require the medical examination of a worker. This request must be made in the form of a written notification order signed by the Director.

Education and instruction in health and safety matters falls under the jurisdiction of section 22 of the Industrial Safety Act, empowering the Minister to make regulations in this area.

4.2.9 Prince Edward Island

Principal Legislation in Occupational Health and Safety

Legislation	Enforcing Authority
Workers' Compensation (R.S.P.E.I. 1974, C.W-10 as amended) Regulations: (1) Industrial Safety Regulations (Royal Gazette 1968 p. 253 amended by 1973 p. 68, 1975 part II p. 27, and p. 104, 1976 part II p. 333 and 1978 part II p. 242) Workers' Compensation Act Regulations (Royal Gazette 1978, part II, p. 239)	Workers' Compensation Board
Steam Boiler Act (R.S.P.E.I. 1974, CS.9) Regulations: Boiler and Pressure Vessel Regulations (Royal Gazette 1967, p. 645, amended by 1971 p. 174 and 1978 part II, p. 85)	Department of Labour

The province's health and safety legislation is covered in 15 Acts and 19 sets of regulations. The key piece of legislation addressing protection from welding fumes is The Workers' Compensation Act (R.S.P.E.I. 1974, C W-10 as amended).

Enforcement of the Act is the responsibility of members and officers of the Workers' Compensation Board, who can inspect premises at any time (section 71), order changes or installation of protective measures (section 71). Where an accident results from failure to comply with an order, the Board may levy fines (section 71), but in any case, section 77 gives the power to prescribe penalties for the violation of any of the Act's provisions. Maximum fine is set at $50 for employer violation, with an additional maximum levy of 3 per cent of the fine if the employer or person defaults on payment.

No specific mention is made of applicable TLV's for airborne contaminants. However, in the Industrial Safety Regulations, section 2, a range of requirements is set out relating to ventilation performance an the proper use of respirators. Section 2.3 requires ventilation in order to reduce contaminants "at least to the maximum safe level."

Section 2.5 also requires that, wherever possible, contaminants be removed at source by the employment of local exhaust ventilation systems, while section 5.12 requires employees engaged in flame cutting of structural steel coated with lead, zinc, cadmium, copper, antimony, mercury or any other ingredient creating toxic fumes, to be supplied with and wear approved respirators.

Section 21 of the Industrial Safety Regulations deals specifically with welding and burning operations, but concentrates primarily upon radiation and fire hazards. Section 21.18, however, does require the use of local exhaust ventilation where welding takes place in a confined space, and section 21.19 requires the use of approved respirators when air samples show that it is necessary. There are no general requirements for air sampling in the Act or its Regulations.

Medical examinations are required only where investigation of a claim is being made. There is no requirement to maintain medical or exposure records for employees, but section 66(5-9) requires the keeping of detailed employment and salary records of each worker by the employer.

4.2.10 Newfoundland

Principal Legislation in Occupational Health and Safety

Legislation	Enforcing Authority
Occupational Health and Safety Act (S.N. 1978, C.23) Not yet proclaimed*	Department of Labour and Manpower
Workers' Compensation Act (R.S.N. 1970, C.403 as amended) Regulations: Workman's Compensation Board (Accident Prevention) Regulations Nfld. Reg. 343/78, also Nfld. Reg. 50/79	Workers' Compensation Board
Boiler and Pressure Vessel Act (R.S.N. 1970, C.24 as amended) Regulations: Boiler and Pressure Vessel Regulations, 1974 (Nfld. Reg. 278/78)	

While Newfoundland's occupational health and safety legislation encompasses at least 19 Acts and 22 sets of regulations, the majority of health protection measures are carried in two pieces of legislation:

The Occupational Health and Safety Act, S.N. 1978, C.23
The Workers' Compensation Act, R.S.N. 1970, C.403 as amended

The Occupational Health and Safety Act has not yet been proclaimed. Its jurisdiction in many instances overlaps with provisions of the *Workers' Compensation Act*, and in particular with sections of the Workmen's Compensation Board (Accident Prevention) Regulations.

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* March 1980

Inspectors under both the Occupational Health and Safety Act (sections 25, 26) and the Compensation Board (WCB Regulations, section 1.07, WCA sections 95, 96) have the power to inspect, order closures and impose fines for contraventions.

The W.C.B. has somewhat broader powers in that special regulations can be issued under the Workers' Compensation Act, requiring the use of prescribed devices to prevent accident or hazardous exposure which might apply to all or a portion of employers covered by the Act (section 95). Both statutes set some requirements for staff to work in the area of education in general safety and occupational health. (O.H.S.A. sections 5(c) and 23(e); W.C.B. Regs. (Accident Prevention), section 95(e).)

Only the Workers' Compensation Act specifies limits on airborne concentrations of potentially toxic substances in workplaces. Section 7.01 of the Accident Prevention Regulations requires the maintenance of these levels to "... recognize Threshold Limit Values...or to conditions satisfactory to the Board."

The current TLV's of the American Conference of Governmental Industrial Hygienists are used in Newfoundland. The Board's Accident Prevention Regulations set guidelines for the proper use of respirators, restricting the use of mechanical filter respirators, and requiring training for users of self-contained breathing apparatus in sections 8.10-8.17.

A specific reference in section 10.13 deals with welding ventilation:

> "When welding or burning operations emit harmful fumes,
> adequate ventilation shall be provided or respirators
> shall be worn by workers exposed to fumes."

Regulations may be made concerning adequate ventilation under the Occupational Health and Safety Act, section 63, though there is no record of that at the present time.

The Occupational Health and Safety Act provides for the identification of hazardous occupations and workplaces. Section 59 may require medical examination, specifying frequency and types of hazard situations.

The form content and maintenance of medical records of selected workers may also be prescribed. In addition, personal physicians or a hospital, at the request of the Occupational Health and Safety Division's Chief Medical Officer, are required to furnish records of specified workers.

Under both Acts, inspectors can enter and remove any material from a workplace as they may require, but there are no requirements for air sampling. However, both pieces of legislation are enabled to make regulations concerning air sampling and general health surveys.

The Occupational Health and Safety Act empowers its staff to order suppliers to stop supplying any materials found to be unduly hazardous (section 28). Section 63(h) allows for regulations concerning equipment markings and hazard identification labelling although no regulations have been written covering this area. The Workmen's Compensation Accident Prevention Regulations require the marking of cannister and cartridge respirators with manufacturers' instructions relating the usage (section 8:14) and protective lifetime.

5. EPIDEMIOLOGICAL REVIEW: SURVEILLANCE AND RECORDS

5.1 Epidemiological Review

The findings from a number of published studies on welder's exposure to fume are presented in this section. No claim is made that the literature has been exhaustively reviewed, or that any rigorous critique has been made of study methodologies. With a few exceptions, most of the studies date from the early 1960's onwards. This covers two decades in which welding technology has made significant advances in the areas of metallurgical alloy formulations and flux composition. Because of these changes some of the studies are unrepresentative of modern conditions.

One of the most troublesome design weaknesses in many of the studies is that little or no information is recorded on the identity and breathing zone concentrations of the hazardous materials involved. This frequently restricts the interpretation of study outcome to general inferences.

Personal communications (Appendix VII) with a number of experienced industrial hygienists, health scientists and occupational physicians have confirmed a common theme that, at the present time, there is not thought to be any really well-supported evidence of an increased risk to welders in the area of respiratory or otherwise systemic disease and subsequent disability. A salient point arising from these discussions is the frequent expression of lack of "well-supported evidence". In no case was a statement made which suggested that there was no occupational respiratory health risk attributable to welding. There are in fact some serious indications that, when compared to the general population, welders do experience standardized morbidity and mortality ratios higher than would be expected. Examples of current studies being carried out in Canada, the USA and the United Kingdom are discussed in Section 5.2.3.

The United Kingdom 1970-1972 Decennial Supplement (Office of Population Censuses and Surveys)(17) records a standardized mortality ratio, SMR*, from death due to pneumonia in the occupational category "Gas,

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* $\text{SMR} = \dfrac{\text{observed deaths}}{\text{expected deaths}} \times 100.$

Electric Welders, Cutters and Brazers" of 122. For this same category, the proportionate mortality ratio, PMR**, for lung cancer was 128.

A NIOSH survey(18) of death records of males over age 20 in the state of Washington during the years 1950-1971, revealed a significant ($p < 0.05$) excess, compared to all male deaths, of deaths in 1376 welders and flame cutters from all diseases of the respiratory system, including cancer, chronic bronchitis and pulmonary emphysema. In addition, there were excessive deaths from cancer of the pharynx, though this was not statistically significant. However, due to the nature of the data retrievable for an investigation of this nature, smoking habits and types of welding fume exposure could not be determined.

In 1976, Menck and Henderson(19) reviewed lung cancer morbidity and mortality in 3938 males aged 20-64 in Los Angeles County. Two periods of time were covered, 1968-70 and 1972-73. Using a 1 in 50 sample from the general census data in the same region, a comparison population of 31 000 white males ages 20 to 64 was generated. SMR's for 417 occupational and 215 industry codes as used in the 1970 U.S. census were computed. Welders, as a group, were found to have a statistically significant increased representation ($p < 0.05$) in total lung cancer deaths than would be expected from their representation in the census. The possible causes of this increased representation however, could not readily be attributed to occupational welding hazard since smoking, other industrial exposure and air pollution factors were not considered.

A prospective mortality study in California during the period 1954-1957 by Dunn _et_ _al_.(20,21), concluded that lung cancer deaths in welders and burners were not significantly greater than expected at the 5 per cent level after correction for age and smoking habits.

Breslow _et_ _al_.(22), examined the biostatistical implications of the occupational background of 518 lung cancer patients from 11 California hospitals during the period 1949-1952. The control group was generated

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** $\text{PMR} = \frac{\text{number of deaths from a given cause}}{\text{total number of deaths, all causes}} \times 100$, over a given time period.

from 518 patients admitted to these same hospitals for conditions other than chest diseases or cancer. Among the 518 lung cancer patients, 14 were male welders with no less than 5 years' occupational experience. Two of 518 controls were welders. The author concluded that welding exposure was a risk factor in the development of lung cancer, but recommended further studies because of the small number of welders in the sample.

In 1976, Ott, Holder and Langer(23) studied causes of death in a cohort of 8171 employees of Dow Chemical Company's Midland, Michigan plant from the year 1954. The SMR for welders of 162, due to malignant neoplasms was higher than expected, though not significant at the 5 per cent level.

Representative of more recent work on welders' fume exposure is a Ph.D. Thesis submitted to the University of Newcastle-upon-Tyne by F. Akbarkhanzadeh entitled "The Relationship between Exposure to Welding Fumes and Changes in Lung Function"(24). The author summarizes the objectives of the study as follows: "Recognizing the need for additional information on the health status of welders, a research program was initiated to investigate the short and long-term effects of airborne contaminants, process variables and cigarette smoking on respiratory disease and pulmonary function in metal arc welders under normal conditions of operation".

We summarize the relevant sections of the author's conclusions as follows:

(a) The prevalence of respiratory symptoms was significantly greater among welders than control subjects, and in both groups, among those who smoked than among non-smokers.

(b) Welders appeared to show significantly increased impairment of lung function compared to the controls. This impairment deteriorated to a greater extent than the controls with advancing years. In general, welders did not have serious pulmonary insufficiency, and most were unaware of any pulmonary disabilities.

(c) Among welders, smokers had the highest frequency of abnormal pulmonary function, but no clear synergism was discernible in acute or long-term effects of welding fume and cigarette smoking.

Ten further studies, selected because they address the more commonly occurring diseases of siderosis and mixed dust pneumoconioses, are summarized in Table 16 and discussed below. A diversity of findings is evident, but the literature on pulmonary impairment in welders generally fails to indicate any reliable correlation between the prevalence of pneumoconiosis and frequency of appearance of lung function deterioration.

(a) Dressen et al., 1947(25)

Study of arc-welders in seven U.S. shipyards. Sample of 3000 welders, about 15 per cent of the welding work force. 4563 X-ray films were evaluated.

Prevalence of abnormal chest X-rays by age is given in Table 10.

TABLE 10

PREVALENCE OF ABNORMAL CHEST X-RAYS

AGE	% MALE WELDERS	% MALE NON-WELDERS
15-24 yrs.	2.6	1.4
25-34	8.4	5.3
35-44	9.9	6.3
≥45	9.9	11.5

Prevalence of abnormal chest X-rays by duration of exposure is given in Table 11.

TABLE 11

PREVALENCE OF ABNORMAL CHEST X-RAYS, %

DURATION	MALE WELDERS NO PREVIOUS INDUSTRIAL EXPOSURE	MALE WELDERS PREVIOUS INDUSTRIAL EXPOSURE
<10 months	5.3	5.9
10-19	5.4	7.6
20-29	6.2	10.6
≥30	11.0	12.3

This study suggests that the frequency of abnormal X-ray changes is related to the duration of occupational exposure (Table 11). In Table 10, the lower prevalence of 9.9 per cent for welders compared with 11.5 per cent for non-welders over 45 years old may be due to the loss of impaired welders from the employment rolls due to disability.

(b) Britton and Walsh, 1940(26)

The authors reviewed chest X-ray films of 286 arc and oxy-gas welders with >5 years' exposure, (average 9 years' exposure).

"Most" welders worked in well-ventilated areas in 14 different plants.

Chest X-ray results:

65 per cent of X-ray films were considered normal;
8.4 per cent revealed stippled lung fields or increased hilar or linear lung markings;
16.4 per cent revealed increased hilar or linear lung markings.

(c) Dobrzynski, 1973(27)

Dobrzynski reviewed chest X-ray films of 1027 manual arc welders over a period from 1961 to 1972 with respect to "type of exposure".

Table 12 illustrates the distribution of X-ray abnormalities, according to mean age and mean duration of exposure.

The authors classified the X-ray abnormalities as pneumoconiosis due to exposure to iron, silica and other dusts.

The duration of exposure to welding was associated with the frequency of appearance of abnormal chest films. Only 1 per cent of group I welders (hull welders in confined spaces) with abnormal chest X-rays had worked for less than 3 years, while over 60 per cent of the cases occurred in welders with over 13 years' exposure.

(d) Schuler et al., 1962(28)

210 arc-welders from various industries in Santiago, Chile: ages from 30 to 60 years, mean of 45 years.

Duration of exposure was 5-25 years, with most exposed for not less than 15 years; 32 were diagnosed as having "clear-cut" pulmonary siderosis, whilst overall (including the 32 diagnosed), 84 per cent gave normal lung function test results together with the absence of respiratory disease symptoms. It is reported that electrodes were covered with carbonates or oxides, or a fine mesh of asbestos.

(e) Kierst et al., 1964(29)

171 welders in the Gdynia Shipyards who were outpatients registered at the clinic for occupational diseases, with welding employment ranging from 1 to 32 years.

Except that exposure to rutile (titanium) covered shielded metal-arc electrode fume was "noted", no fume levels or other information were recorded.

A control group of 43 hull-fitters with 1 to 15 years' occupational exposure ranging in age from 18 to 45 years was used.

The results are presented in Table 13.

TABLE 12

PREVALENCE OF ABNORMAL CHEST X-RAY FILMS IN MANUAL ARC WELDERS ACCORDING TO WORKING CONDITIONS

				MEAN AGE (YEARS)		MEAN EXPOSURE (YEARS)	
GROUP	NO.	WORKING CONDITIONS	ABNORMAL CHEST X-RAY	WELDERS WITH ABNORMAL CHEST X-RAYS	WELDERS WITH NORMAL CHEST X-RAYS	WELDERS WITH ABNORMAL CHEST X-RAYS	WELDERS WITH NORMAL CHEST X-RAYS
I	650	Hull welders in confined space	77 (12%)	38.6 ± 7	32.9 ± 9	14.0 ± 5	9.2 ± 6
II	46	Container welders outside shipbuilding industry	6 (13%)	41.5 ± 6	40.3 ± 8	13.4 ± 5	11.5 ± 9
III	156	Shipyard welders in open air	5 (3%)	35.5 ± 5	34.6 + 8	11.0 ± 2	10.2 ± 5
IV	175	Welders in other industries	4 (2%)	37.7 ± 9	38.2 ± 9	11.7 ± 7	12.2 ± 6

Adapted from: "Effects of Welding on Health"; AWS 1979(1).

TABLE 13

CLINICAL, FUNCTIONAL, AND RADIOLOGICAL RESPIRATORY SYSTEM ABNORMALITIES IN POLISH SHIPYARD WELDERS

CHEST X-RAYS PICTURE		NUMBER (%) OF WELDERS	NUMBER (%) OF CONTROLS	CLINICAL AND FUNCTIONAL FINDINGS IN WELDERS
Group I:	no chest X-ray abnormality	30 (19%)	25 (59%)	None
Group II:	slight localized shadowing	63 (37%)	18 (41%)	None
Group III:	linear shadows and small nodular opacities in peripheral lung fields	64 (37.4%)		Chronic bronchitis, pulmonary emphysema, and effort dyspnea in 6 welders; decreased vital capacity in 19 welders
Group IV:	"snowstorm appearance", diffuse micro-nodular opacities	11 (6.4%)		Chronic bronchitis and effort dyspnea in 11 welders; beginnings of corpulmonale in 5 welders; decreased vital capacity in 5 welders

Adapted From: "Effects of Welding on Health"; AWS 1979(1).

The study indicates that: (i) for both welders and controls, the percentage of abnormal chest films was proportional to the duration of occupational exposure, and (ii) the siderosilicosis caused little pulmonary fibrosis or interference with pulmonary circulation even after long exposures to welding fumes, in contrast to what would have been obvious disability in the case of true silicosis.

(f) Spacilova and Koval, 1975(30)

The authors compared X-rays of 37 arc-welders from various industries in Prague.

23 welders worked in confined spaces with exposure to dust levels of 49-145 mg/m^3 for 13 per cent of yearly worktime, while 14 welders were classified as "open air" welders.

Age and exposure classifications and the results are given in Table 14.

TABLE 14

X-RAY ABNORMALITIES AND WORKING CONDITIONS OF WELDERS IN PRAGUE

			Age		Exposure (yrs)		
	No.	Abnormal X-Ray	Mean Age	Range	Mean Duration	Range	Working Conditions
Group A:	23	18	42	30-56	18	10-32	13% of yearly work-time in confined spaces; dust levels of 49-145 mg/m^3
Group B:	14	12	46	31-64	16	3-34	Open-air welding; no dust; basic elec-rodes used

Spacilova and Koval, 1975(30)

The study reports that in 4 group A welders of 25 or more years' exposure, nodular opacities indicative of fibrosis were noted, but the substances causing the opacities were not identified. Eight persons from each group had chronic bronchitis and reduced pulmonary function.

Reporting of X-ray findings based on small samples from poorly-defined environments has limited use in comparing the effects of confined space versus "open air" welding.

(g) Gillon and Marchand, 1963(31)

The authors examined chest X-ray films of 500 arc welders with more than 5 years' exposure in gas tungsten arc and shielded metal arc welding. Welders with silica exposure or histories of lung disease were excluded from the study.

Reticular or nodular densities in both lung fields were found in 27 cases, (5.1%). No apical involvement or diaphragmatic or cardiac abnormalities were involved.

A statement is made that (unspecified) lung function tests were normal in the welders with abnormal chest films.

(h) Hunnicutt et al., 1964(32)

From a shipbuilding plant of about 20 000 total employees, 100 welders and 100 controls were randomly chosen for a study of smokers versus non-smokers.

The sampling was controlled for:

(a) Only welders under age 60 with at least 10 years of experience were chosen.

(b) Both welders and controls were chosen to exclude those with chest and lung lesions, asthma, a past history of exposure to known irritating dusts or fumes, or with cardiovascular disease.

No information about breathing zone concentrations, materials used or ventilation controls was recorded.

A summary of the findings is presented in Table 15 where symptoms of lung disease (cough, expectoration, dyspnea, and wheezing) are tabulated according to smoker/non-smoker with normal lung function and lung deficit.

TABLE 15

CHRONIC RESPIRATORY SYMPTOMS WITH AND WITHOUT LUNG DYSFUNCTION BY SMOKING HABIT AND OCCUPATION

	WELDERS								UNEXPOSED CONTROLS							
	SMOKERS (N=71)				NONSMOKERS (N=29)				SMOKERS (N=59)				NONSMOKERS (N=41)			
	NORMAL LUNG FUNCTION		LUNG DYS-FUNCTION		NORMAL LUNG FUNCTION		LUNG DYS-FUNCTION		NORMAL LUNG FUNCTION		LUNG DYS-FUNCTION		NORMAL LUNG FUNCTION		LUNG DYS-FUNCTION	
SYMPTOM	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
Cough	6	9	15	21	3	10	1	3	8	14	2	3	0	0	1	2
Expectoration	4	6	10	14	3	1	1	3	5	8	2	3	0	0	1	2
Dyspnea	4	6	3	7	2	7	1	3	1	2	1	2	0	0	0	0
Wheezing	2	3	10	14	1	3	0	0	1	2	1	2	0	0	0	0

Hunnicutt et al, 1964(32).

The authors concluded that the various symptoms of lung disease correlated with the frequency of findings in pulmonary function in the various groups. The symptoms occurred twice as often among welders who smoked than among welders who didn't smoke.

In X-ray examinations of welders with an average of 18.5 years' work experience, there was evidence of pulmonary siderosis in 34 per cent. No other classification of X-ray abnormality was recorded.

(i) Kleinfeld et al., 1969(33)

Kleinfeld, 1970(34)

The authors compared 25 welders with 20 age and residence-matched controls having no occupational exposure to dust. The number of cigarette smokers was similar in welders and controls.

The following fume concentration levels were recorded:

inside face shield, iron oxide	0.65 - 47 mg/m^3
outside face shield, fluoride	2.7 mg/m^3

No further data on welding process, materials or ventilation was provided.

The study concluded that there was no significant difference in pulmonary function tests between:

(a) welders and controls, or
(b) between welders exposed for less than or greater than 20 years.

(j) Antii-Poika et al., 1977(35)

Compared X-ray findings, pulmonary function and lung disease symptoms in 157 welders and 108 controls. The welders had at least 3 years of welding at least 3 hours per day. The fume levels were "up to 9 mg/m^3" measured outside the helmet, resulting from the use of basic covered electrodes to weld mainly mild unpainted steels.

The findings from this study were:

(a) There was a significantly greater prevalence of simple chronic bronchitis in welders than in controls ($p < 0.01$), but,
(b) Reports of persistent cough and dyspnea were more frequent in the controls than in the welders.

TABLE 16

PREVALENCE OF WELDERS WITH CHEST X-RAY PICTURES CHARACTERISTIC OF SIDEROSIS OR MIXED-DUST PNEUMOCONIOSIS

Author	Ref.	Year	Workplace		Prevalence, %	Duration of Work (Years)
(a) Dressen	25	1947	Shipyard	Men	36.1	-
				Women	17.3	
(b) Britton	26	1940	Manufacturing		35	>5
(c) Dobrzynski	27	1973	Ship's Hull, confined space:		12	9.8 (mean)
			container welding (non-shipbuilding);		13	11.7
			shipyard, open air;		3	10.2
			other industry		2	12.2
(d) Schuler	28	1962	Various		15	5-25
(e) Kierst	29	1964	Shipyards		6.4-37.4	1-15
(f) Spacilova	30	1975	Manufacturing:			
			A. Confined spaces		78	18 (mean)
			B. Open air		85	16 (mean)
(g) Gillon	31	1963			5.1	-
(h) Hunnicutt	32	1964	Shipbuilding		34	10-35
(i) Kleinfeld	33 & 34	1969	Manufacturing		32	-
(j) Antii-Poika	35	1977	Non-shipyard		0	36 (mean)

TABLE 17

SAMPLE OF CROSS-SECTIONAL EPIDEMIOLOGICAL STUDIES OF CHRONIC RESPIRATORY EFFECTS IN WELDERS

Author	Ref.	Workplace*	Process/ electrode type	Metal welded	Exposure Years	Statistically signif. excess of chronic lung disease symptoms	Statistically signif. impairment in lung function indices
NIOSH	18	-----	-----	-----	-----	Yes	---
Ross	36	Shipyard	-----	-----	-----	Yes, in 50-59 yr. old	No
Wilhelmsen	37	Shipyard, confined	SMAW/Basic	Mild steel and primed metal	Mean 17±8	Yes, in nonsmokers	Yes, in nonsmokers
Peters	38	Shipyard repair Confined	GMAW, GTAW GMAW	Cr, Mn, Ni alloys Mild steel, aluminum, stainless steel	-----	-----	Yes
Fogh	39	Shipyards, or engine and boiler makers	SMAW	Mild steel, 30% with anticorrosion primer	>5	No	No
Fogh	40						
Barhad	41	Shipyards, large ships and confined spaces	SMAW/Basic FCAW, Oxygas		>5	Yes	
Ulrich	42	Shipyard	GMAW	-----	-----	Yes	No

*Often, other exposures were implied but not reported.

(c) Age, smoking habits and duration of exposure appeared not to affect the rates of simple chronic bronchitis.

(d) The mean values of pulmonary function test readings were similar for all welders with or without concomitant findings of chronic bronchitis.

On the question of chronic respiratory conditions in welders as an occupational group, the findings from a sample of eight cross-sectional studies(18,36-42) are summarized in Table 17.

5.2 Health Surveillance, Records and Systems

5.2.1 Health Statistics

Morbidity and hospital statistics are collected by Statistics Canada. Selected data is published as the "82" series of Public Health Statistics. No occupational coding is done in an easily returnable form. Coding is based on either the 3-digit International Classification of Diseases (ICD), 8th Revision, or on the less detailed Canadian diagnostic list adapted from the ICD.

As a pilot exercise, retrieval of information using the ICD-Adapted, 8th Revision "E code" (cause external) was attempted from computer tapes of hospital admissions and separations. Information on possible fume inhalation in welder patients did not show up. This may be due simply to a lack of hospital admissions of welders needing treatment for welding fume exposure. A more likely explanation is probably the non-recognition of signs and symptoms related to welding occupation exposure, coupled with a failure to adequately report patient histories with regard to occupation.

Morbidity information is compiled from form HS-1 (patient-days) and form HS-2 (income)(43,44). These forms are uniform across the country. They report the occupation of the patient as well as information on reimbursements for Workers' Compensation cases treated at the hospitals.

Admission and separation forms are the principal source of morbidity statistics. These are standard only within each province, where initial data compilation is performed, and are also instruments for the calculation of health care transfer payments.

Hospital annual returns differ from admission/separation data in that they record all hospital discharges irrespective of the patients' normal place of residence. The preliminary attempt to retrieve useful occupational information from computer tapes of hospital admission/separation forms maintained at the Hospital Morbidity Section, Health Division, Statistics Canada, was thus unsatisfactory. It may be possible at some future date to retrieve information of value by removing data on the basis of the desired E-code and then backtracking for occupation and Workers' Compensation information. However, there may still be information gaps due to the non-recognition of welding occupational factors in diagnosis. This lack of occupational exposure information occurs frequently with Workers' Compensation data systems.

The Vital Statistics Division of Statistics Canada maintains a machine readable death certificate bank from 1950 onwards. Data prior to 1950 is not currently in machine readable form. Occupational coding information is submitted at present only by the Province of British Columbia, and this information appears to be potentially retrievable. Occupational data has already been recovered from the bank (Section 2.3). While not coded by occupation, death certificates contain occupation as well as cause of death information according to the ICD.

The Division staff(45) recommend the following information be gathered for the generation of a nominal roll of study subjects:

1. Birth data - year, month, day.
2. Full birth name.
3. Birth place.
4. Sex.
5. Place of residence.
6. Reliable information on year last known alive.

Several companies are currently undertaking studies in occupational epidemiology. These include an INCO study conducted by Robin Roberts of McMaster University and a Falconbridge Nickel Co. study conducted by Harry Shannon also of McMaster. Both of these are addressing causes of death in nickel workers by retrospective cohort analysis. The studies are ongoing but we are advised that some preliminary findings may be published by the end of 1980.

A surveillance study of employees of Eldorado Nuclear is currently being undertaken by Dr. John Abbott (Eldorado) and Dr. Geoffrey Howe (University of Toronto)*. This is a cohort retrospective study designed to link unusual morbidity and mortality records with possible causal factors in the workplace.

5.2.2 Compensation Mechanisms

Compensation statistics generated under the Government Employees Compensation Act are centrally computerized in the Occupational Safety and Health Branch, Statistics Section, Labour Canada. The data is based upon federal employees claims made to provincial Workers' Compensation boards. Occupational coding is at the two-digit level, and consequently is of limited use in the analysis of welders' claims. (Welding is grouped with "83" - machinery trades). Only two codes are of value in identifying casual factors behind incidents of fume exposure; 0900 chemical exposures and 5000 ozone. Both of these are too general in nature to be of help in identifying welding related claims. The document "Work Injury Experience and Cost in Canadian Industry"(46), provides an example of the type of information retrievable from Labour Canada Statistics Section.

In cooperation with Treasury Board, claims data relating to employees covered by the Government Employees Compensation Act are maintained with the Occupational Health and Safety Branch of Labour Canada. From this data bank, occupation (by job title), province of claim and cause, can be identified for allowed claims only. Accident and compensation reporting procedures by employer category are summarized in Table 18.

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* National Cancer Institute of Canada
Epidemiology Unit, Faculty of Medicine

TABLE 18

ACCIDENT COMPENSATION RESPONSIBILITIES BY EMPLOYER CATEGORIES

	SAFETY REGULATIONS	ACCIDENT COMPENSATIONS	REPORTING SYSTEM	TYPE OF INFORMATION
Federal Departments*	TB Safety Policy	GECA	1) C45** 2) Supervisors' Accident Investigation Report	Compensation, Accident Investigation.
Crown Corporations*	Part IV	GECA	1) APC 66 2) C45** 3) APC 56	Same as above.
Federal Works, Undertakings and Businesses	Part IV	WCB	1) APC 66 2) APC 56	Work-Injury, Accident Investigation.
Others	Provincial or other Regulations	WCB	WCB Annual Report	Work-Injury.

* These groups use ANSI standard classification.
** Accident Compensation System.

Mortality and disabling workplace injuries must be reported for all federal jurisdiction claimants. These records may be searched manually for occupational details. Cause coding is on the two-digit level, which is, again, inadequate for identification of the welding factor.

Provincial Compensation Boards document injury claims in their annual reports. Certain Boards make more detailed claim reports, according to their own specific needs, but still the most detailed occupational coding found was at the two-digit level. Frequently, industry classifications were used, which are even further removed from the welding situation, or any occupational category for that matter.

In 1978, a National Statistics Program on Work Injuries, with the participation of Ontario, Saskatchewan, and British Columbia, was discontinued by Statistics Canada. The program has recently been revived, and data will be collected on a national basis in the near future. According to the Hospital Morbidity Branch, Health Division, Statistics Canada, the initial material is only expected to be coded to the two-digit level. Variations in claim waiting periods, adjudications and definitions of disease would prevent a simple allocation of claims on a national basis. Also, because of the litigational and pseudo-judicial nature of compensation claim settlements, certain inconsistencies will arise between the various provinces due to variability in the definition of compensable injury and disease. This would tend to disguise trends in the frequency of occurrence of industrial injury and disease on a national basis.

As in other cases of occupational disability, claimants who have been exposed to welding fume must rely on the effectiveness of Compensation Board procedures in identifying causal factors to justify their claim.

In The Dimensions of Industrial Disease(47), T.G. Ison identifies several factors giving rise to the frequent inability of Compensation Boards to appropriately compensate industrial disease victims. While we are not in a position at this time to overtly criticize Compensation Board procedures in Canada, Dr. Ison's points do tend to confirm our suspicions about the usefulness of claims statistics for evaluating welder's occupational health risk.

In reviewing the points Dr. Ison raises, we agree that some of these problems are:

1. The inadequate application of knowledge regarding the etiology of occupational disease.
2. On the national scene there is no systematic program for monitoring health effects or for the proper identification of hazardous materials; for example, fume composition arising from welding rods. This contributes to difficulties in obtaining correct diagnoses.
3. Long latency periods in many occupational diseases reduce the prospects of identifying causal agents in the workplace.
4. Etiologic factors may not be revealed by clinical observation or by questioning patients, but only by epidemiological research. A systematic national program of research into the incidence and causes of industrial diseases has not been carried out.
5. In the majority of cases where a worker is suffering from a disease, a claim for compensation is unlikely to be filed unless the disease is recognized by the attending physician as resulting from employment. Relating to this problem, an opinion is expressed that current occupational medical education programs for physicians are inadequate.
6. The perceived criteria by which antecedent claims for a given industrial disease have been adjudicated may serve to increase or decrease the number of workers filing claims for the same disease, thus distorting incidence and prevalence statistics.
7. The relative roles of law and medicine in claims adjudication are poorly defined and frequently result in a role reversal, where doctors become responsible for essentially legal matters and lawyers find themselves pursuing medical matters.
8. Conditions and benefits attached to current medical insurance programs may dissuade some workers from making compensation claims and, consequently, the number of claims may never reflect the incidence and prevalence of industrial disease.

Further comment by Dr. Ison has a bearing on welders and their claims for respiratory disability:

> "A tendency in claims adjudication has sometimes been to jump from the proposition that a disease is not usually* caused by employment, to the conclusion that the particular claim should be denied ... In British Columbia prior to 1975 the practice was that all claims for bronchitis and emphysema were denied, unless the bronchitis or emphysema was incidental to another compensable disease."

The Ontario Workmen's Compensation Board return for claims allowed in 1971 and 1973-78 (Appendix VIII), illustrates a typical reporting procedure in that, of 10 categories of toxic exposure likely to be experienced by welders, only one, "welding fumes - metal fume fever" is actually allocated for welders. Moreover, "metal fume fever" is an acute effect of exposure to welding fume (primarily to zinc fume), and diagnostic procedures for claims adjudication would probably not stretch to the consideration of simultaneously occurring respiratory hazards and their possible sub-acute or chronic effects.

Our findings so far, regarding the utility of existing Canadian health statistics for welding health risk studies, indicate that a workable data base is not readily available.

5.2.3 Current Studies: Epidemiology

Two Canadian epidemiological studies of note have been able to provide information on health risks experienced by welders.

The first is a study of bladder cancer risk by occupation and other factors, carried out by Dr. G.R. Howe and colleagues(48), conducted in British Columbia, Nova Scotia and Newfoundland. This case control study showed a significantly elevated bladder cancer risk in welders of 2.8 (95 per cent confidence limits; 1.1-8.8).

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* The underline is ours.

The second study, supported by a grant from the National Cancer Institute of Canada, is being conducted by Dr. G.R. Howe, J. Lindsay and A.B. Miller(49). This uses a computerized record linkage procedure based on an approximate 10 per cent sample of the Canadian workplace. Study data was accumulated from Social Insurance Numbers (SIN) data routinely collected by federal statistics agencies between 1942 and 1971 on individuals whose SIN ended in the digit '7'. The data was collected from employers, and thus the industry and occupation for such individuals were recorded (and then converted to machine readable form).

The study uses data collected between 1965 and 1971 since this was able to be computerized for subsequent cohort follow-up. The cohort, derived from SINs containing occupational history, were linked to the Canadian mortality data base and national cancer incidence reporting system, maintained by Statistics Canada. The intention is to update the study at five-year intervals. The cohort comprised approximately 450 000 males and 230 000 females. A technique for computerized record linkage is described by H.B. Newcome of the National Research Council(50).

Because of the limitations of the data base, the authors suggest a limited and judicious use of results, confined to the following purposes:

1. To generate new hypotheses concerning occupational health risk for subsequent testing in other studies.
2. To test the validity/significance of observations already made in previous studies. The data is capable of correlating occupation with 57 causes of death, including 20 cancer types.

The work by Howe et al. is particularly notable in developing systematic epidemiological studies of occupational disease. It appears to be a successful attempt at computerized record linkage, while maintaining confidentiality in personal medical information.

Dr. Howe has agreed to generate welder-specific data. This will take a little time, and will be released to us subject to his own interpretation of the results.

Several British studies are currently under way using record linkage for large cohorts. A 1 per cent sample of the 1971 census population of

England and Wales studied by E.D. Acheson of the University of Southampton Medical School(51) in conjunction with the Office of Population Censuses and Surveys, has generated a cohort of about 500 000 persons for evaluation concerning, among other things, occupational exposure factors.

Mention should be made also of two studies of current concern in the United States, which can be expected to reveal meaningful data on welder health risk. The first, by the National Cancer Institute, is a cancer study being carried out on a population of wartime tank welders. This was precipitated following the appearance of positive "Ames Test"* findings in the analysis of welding fumes from stainless steel containing chromium and nickel.

Further details are pending at the time of writing of a NIOSH study covering 8000 metal workers, including 2000 welders. The parameters of the population at risk, and of disease incidence/prevalence, are not known at this time. Further documentation of welding occupational health risk should include the findings of this study, when available.

The studies discussed above are examples of work in hand currently, on the subject of welder's health. Further inquiry, to identify other activity in the area, is suggested pursuant to this report.

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* The Ames Salmonella/microsome mutagenicity test(52).

6. LABOUR INVOLVEMENT

6.1 Union Membership

The labour movement in Canada was reported to represent, at the beginning of 1978, 39.0 per cent of the non-agricultural labour force(53). Of these workers, 67.2 per cent were members of unions affiliated with the Canadian Labour Congress (CLC), 5.4 per cent with the Confédération des Syndicats Nationaux (CSN or CNTU) and 0.8 per cent with the Confederation of Canadian Unions (CCU). About 20 per cent of unionized workers belonged to independent national unions.

Eighteen unions reported memberships greater than 50 000 with the Canadian Union of Public Employees (CUPE) and the United Steelworkers of America (USW) topping the list; 47.4 per cent of unions operating in Canada had U.S. headquarters(53).

The Canadian labour movement is a hybrid of British, American, and Canadian traditions with an accordingly varied approach to workplace health problems. The majority of unions retain trade-descriptive names based upon their original area of concern. Due to the wide applicability of welding and related skills, therefore, we find the national welder population widely distributed among many unions. Moreover, unions have arranged their locals upon industrial rather than trade lines in response to their own organizational imperatives and labour relations legislation. Consequently, we have found that there are at least 30 organizations representing welders, according to the various industries in which welding is carried out.

Exceptions to the industry-based system are the public service unions. These tend to organize and bargain along occupational lines with their provincial and federal government employers. Generally speaking, public service unions are readily able to identify the number of welders they represent, but upon further investigation we find that they tend to rely for this information on employer's records. Consequently, in attempting to tabulate Canadian welders, we must bear in mind that labour organization returns may duplicate government estimates. (Section 3.3.3

discusses labour organizations as sources for deriving estimates of the welding population for epidemiological study purposes.)

Individual unions have found great advantage in amalgamating with labour Centrals, the CLC being probably the most prestigious and well-known of these. Regional groups affiliated with the Central meet formally as federations, councils and other bodies in order to pursue the local business of the Central.

In interviews conducted with a selection of unions representing large numbers of welders, it was found that membership occupational records are not readily available. In most cases, surveys would have to be conducted through plant-based union officials in order to produce a reasonable estimate of welder members.

Collective agreements, while often listing separate pay rates by occupation, rarely indicate the actual number of workers covered by the agreement. In the construction unions, due to the nature of the hiring system, the flexibility of skills among members, and the traditionally high level of mobility in construction trades, the task of identifying welders and welding situations appears to be particularly difficult.

We have been unable to identify the number of welders who are union members.

6.2 Occupational Health Programs

6.2.1 Claims and Records

All of the unions interviewed said they were able to identify the number of welders who had made Workers' Compensation claims in the past two years, given sufficient time to manually search their files. We were told on several occasions that many of the chronic respiratory impairment and breathing problems experienced by welders are extremely difficult to prove as being occupationally induced. This problem appeared to exist in all the provincial jurisdictions and consequently a search of compensation claim records is unlikely to reflect the true prevalence of respiratory disability in welders caused by exposure to welding fumes.

We were unable to find a union that kept occupational health records. In a few instances where a deterioration of health status in certain occupational groups suggested adverse working environments, investigations into the causes have been put in hand. Some of this material has been published. The C.A.S.A.W. study of aluminum smelting is an example of such a study(54).

The United Autoworkers have negotiated significant access and surveillance rights in connection with union-sponsored health inspection of the workplace. CUPE, United Steelworkers, and CAIMAW all have produced guideline contract terminology in the occupational health area to assist local representatives in labour negotiations(55,56).

Some of the objectives relating to occupational health and safety, currently being pursued in contract negotiations, are:

1. Full and regular inspectional access by union officials.
2. Paid safety training leave.
3. The carrying out of appropriate monitoring, and provisions of monitoring equipment to union-designated employees upon request.
4. Full joint labour-management accident and "near miss" investigation.
5. Full disclosure of any potentially harmful substance or equipment used by workers.
6. Special employee fund administered by the union to promote occupational health and safety.
7. Full right, free of disciplinary action to refuse to work in conditions perceived to be unsafe by the worker.
8. The right to pursue health and safety problems through the grievance procedure.

The CLC is currently compiling a guide to safety and health contract language. All unions expressed some frustration with their attempts to effectively intervene in matters of unsafe or unhealthy working conditions, and all pointed out that the "minimum" standards prescribed in occupational health legislation were often interpreted by employers as "maximum" considerations.

Most union representatives expressed dissatisfaction with current health and safety legislation. A recurrent theme with regard to welding was that statutory requirements for proper ventilation should be in the form of specific engineering standards and performance criteria. In addition, it is held that welding materials (consumables) should be classified according to their "rate" of fume generation, and that this information should be taken into account when specifying engineering controls.

The sentiments expressed by certain representatives regarding the need for the determination of fume generation rates for ventilation design purposes is in substantial accord with the priorities of the WIC, the CWB and the Canadian Standards Association.

6.2.2 Health and Safety Education

All unions and labour Centrals interviewed had more or less the same basic approach to health and safety education. For those members able to claim paid educational leave, longer and more detailed training programs are offered, generally taught by qualified union staff.

The Ontario Federation of Labour (OFL) has established a training program with funding from the Ontario Government. Its primary aim is to train safety and health committee members with the expectation that graduates will, in turn, conduct training seminars within their own locals.

The OFL has produced a training manual(57), as well as an extensive library of health and safety audiovisual aids. Weekend seminars are regularly presented by most labour organizations and these are addressing more and more the issues in occupational health and safety.

The CLC, under federal grant and through its own Centre for Labour Studies, has produced a substantial amount of material for use in occupational health educational programs.

There were no programs reported to be specifically designed to cover welding health hazards. However, the educators interviewed said that they would be able to provide specialized welding seminars if requested to do so.

7. INDUSTRIAL HYGIENE CONSIDERATIONS

This section summarizes some of the principal issues concerning the identification and control of health hazards due to fume exposure in welding and associated activities. Selected organizations at present demonstrating concern or active in hazard evaluation and control are noted.

Established sources of information with regard to specific topics are listed; one of the predominant areas of concern at the present time being the characterization of fume associated with the various types of filler materials in common use.

7.1 Fume Characterization

Work has been carried out by various welding establishments to develop a relationship between types of electrode and the composition of the fume they generate. We believe that continued effort in this area should provide the groundwork for the implementation of more effective fume hazard control practices.

The American Welding Society has placed much emphasis on the evaluation and control of welding health hazard, with particular attention being given to fume generation studies. The Society's publication, "Fume and Gases in the Welding Environment"(7), reports average ranges for fume generation rate, and weight of fume per unit weight of deposited metal, for a selection of 32 electrodes in common use, along with a more detailed analysis of gaseous components of the fume. A more recent AWS publication, "Effects of Welding on Health"(1), describes further studies on fume characterization, together with a comprehensive review of health effects and medical findings.

In Europe, the International Institute of Welding is involved in classifying electrodes according to their fume characteristics. The objective is to produce baseline data for the purpose of specifying exhaust ventilation systems. The Swedish Standard SS062801(58), sets out to group covered electrodes in one of seven categories according to their calculated Nominal Hygienic Air Requirement, NHL, which is the volume of fresh air needed per unit of welding time. This standard uses Threshold

Limit Values given in Swedish Standard SS062802 (Nov. 1969), for the calculation of NHLs(59). A further discussion of this procedure is given by E.J. Magnusson in "Svetsaren - a Welding Review"(60).

The Canadian Welding Bureau has submitted (February 1980) recommendations to the CSA Steering Committee on Welding that a Technical Committee be formed to develop standards and codes of practice for controlling the health hazards of fume exposure. Pointing out that the existing CSA code for health and safety in welding CSA 117.2(61) does not adequately address the toxic effects of welding fume, the CWB has emphasized the need for standards relating to air sampling and analysis, and for ventilation equipment performance and maintenance criteria. Further recommendations to the Steering Committee include the need for electrode classification by fume characterization, consumable materials warning labels, the development of performance standards for respirators, and further emphasis on employee education in occupational health hazards.

An analysis of potentially hazardous materials in consumable electrodes from various U.S. manufacturers is contained in an Industrial Hygiene Standard produced by the Gulf Oil Corporation in 1974. The percentages of total fume composition of fluorides, chromium, manganese, nickel and carbon monoxide are given, although the measurement and analysis method is not.

Ontario Hydro, in association with the Welding Institute of Canada, is currently carrying out a welding fume evaluation project sponsored by the Canadian Electrical Association(62). One of the objectives is to develop a reliable methodology for the measurement of fume generation rates of welding consumables in common use in Canada, with specific reference to those used in the electrical power plant construction industry.

In 11 recent surveys of railway maintenance and repair shops carried out by Labour Canada and Medical Services Branch of the Department of Health and Welfare, four reported the type of welding consumable in use. The scope of these surveys did not include the identification and measurement of fume from each specific electrode type. These studies could well serve to lay the groundwork for further investigation into electrode fume classification by the Occupational Safety and Health Branch of Labour Canada.

The Algoma Steel Corporation has made an evaluation of 32 welding rods in the form of Materials Safety Data Sheets, which the company has agreed to make available for this study (Appendix IX). These provide guidelines on health hazard rating and hazard control requirements, though an actual analysis of chemical substances comprising the fume, is not presented. Safety data sheets such as these are becoming more and more available in industry as potentially hazardous materials are identified. They are very useful in presenting general hazard information to workers and supervisors directly responsible for the safe handling and usage of these materials.

A comprehensive report by the U.K. Department of Employment and productivity entitled "Fumes from Welding and Flame Cutting"(63) documents fume levels in the shipbuilding and repair industry in North-East England, according to type of electrode. The findings of this survey could usefully be reviewed for applicability to the Canadian welding environment.

7.2 Respiratory Protection

The use of personal respirators, as a method of protecting workers exposed to welding fume, is an issue causing some contentious debate. Industrial hygiene practice supports, unreservedly, the view that no worker should be required to wear a respirator as a normal requirement of his job. The only acceptable control of respiratory hazards is that which prevents hazardous concentrations from appearing in the worker's breathing zone in the first place.

There are occasions however, where the control of exposure to levels below the TLV is impracticable in certain industrial situations. These include maintenance procedures, special or infrequent operations, and plant upset conditions.

Welding and associated processes are, by the very nature of the function performed, widely used in maintenance procedures. Thus, in contrast to potentially hazardous processes which are permanently located and amenable to engineered hazard controls such as local exhaust ventilation hoods and ducting, the welding process is frequently transportable.

Portable ventilation apparatus is quite widely available, but its effectiveness for particulate and gaseous capture and safe removal deserves critical evaluation.

Consequently, respirators are at the present time found to be necessary in many welding situations. This necessity is too infrequently recognized, with the result that respiratory exposure is higher than it need be.

It bears repeating that the use of respirators in normal day-to-day work situations can only be accepted as an interim measure. Nevertheless, we recommend that, for the period during which engineering controls are inoperative, proper programs for respirator selection and usage be implemented. This survey has identified deficiencies in welding respirator program management.

Information on respiratory protection is available from the U.S. National Institute of Occupational Safety and Health(64), U.S. Department of Labour - OSHA Occupational Safety and Health Standards(65), and the American National Standards Institute "Practices for Respiratory Protection" sponsored by the U.S. Mining Safety and Health Administration(66).

Examples of advisory documents on work practices directly addressing welders' health and safety are the AWS publication of the ANSI Standard, Z49.1 (1973) "Safety in Welding and Cutting"(67), the Canadian Safety Council's Data Sheet No A-1 1976(68), the British Welding Institute's "Facts about Fume"(69), a succinct summary of welding respiratory hazards and engineering controls by the Midden Corporation(70), and the U.K. Health and Safety Executive's Guidance Note MS15, which identifies common welding processes and associated hazardous agents(71).

7.3 Ventilation

The removal of airborne contaminants from welding, brazing, flame cutting and metal spraying operations can usually be achieved with permanently installed exhaust systems, except for two situations which present special problems. These are; transportable operations required for maintenance and repair procedures, and large component assembly requiring an extensive shop floor area. We may include in the second category, electrical generating equipment manufacture and shipbuilding

Without actual numbers to prove the point, there are indications that the risk of exposure to fume is considerably higher in maintenance and large assembly situations than it is on the permanently installed production line.

For welding ventilation, both local exhaust and dilution methods are widely used. Frequently however, the ventilation apparatus does not adequately control the fume, though this is, to maintain perspective, a deficiency in hazard control ventilation at many industrial processes besides welding. Ineffective exhaust system performance arises for a number of reasons, including inappropriate initial design, careless operation and negligent maintenance. Effective ventilation maintains airborne concentrations of all substances found in welding fume to levels which present no health risk to the welder.

The maximum permissible level of exposure implied here continues to be open to some debate. The ACGIH time-weighted Threshold Limit Value of 5 mg/m^3(72), is applied, like most TLVs, as a guideline based on the best available information with regard to the acute and long-term effects of exposure. This TLV has appended to it a number of qualifications, including its coverage of welding fume components "Not Otherwise Classified", (NOC).

Superimposed subsequently on the welding fume TLV of 5 mg/m^3, which is a gravimetric assay of airborne particulate matter, are the TLVs for other identifiable components of the fume. These arise from the base metals, fluxes and coatings, and include oxides of nitrogen, ozone, carbon monoxide, fluorides and specific metals. Once identified, these substances would fall outside the category of "Not Otherwise Classified".

Thus, the design of an adequate ventilation system requires initially, a clear understanding of the substances contained in the fume and their maximum permissible airborne concentrations. Subsequent considerations include fume generation rates, production rates, size of workpiece and emission capture zone requirements, work practices, simultaneously occurring non-chemical hazards, and the cyclical nature of the actual application of the weld.

Work practices are among the more important considerations, since the most well conceived ventilation system can be rendered ineffective if it interferes with the performance of the task, or if it requires adjustments which are inconvenient and troublesome to the welder.

The essential requirement for eye protection, the traditional welder's helmet, often presents a complication when designing exhaust ventilation for certain welding and associated high-energy arc operations. The problem is aggravated when the operations are carried out in enclosed or semi-enclosed spaces.

Ozone can be generated within a sphere of variable radius from the point of arc discharge, and requires special ventilation considerations, since, unlike the other potentially hazardous materials, it is not released only at the point source of the weld(6,7,8,73).

7.4 Summary

Insofar as a brief look at some industrial hygiene topics may serve to explain the nature of respiratory hazard associated with welding and related occupations, these have been introduced for the purpose of initiating further discussion, albeit beyond the scope of the present report.

The establishment of a set of guidelines for welding ventilation systems is a priority. This is contingent upon the reliable identification of the toxic materials occurring in different types of welding processes, together with their maximum permissible workplace exposure levels. To support this endeavour, welding rod fume identification programs should be accelerated, recognizing that this will require manufacturers of rod and other consumables to disclose the formulation details of their products.

It is equally apparent that guidance in the selection, use, maintenance and protection limitations of respirators is needed by both employers and employee representatives alike. In this area there are grounds for particular concern across industry as a whole, because of the dangers of false security arising from faulty respirator selection, application and replacement schedules.

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APPENDIX I

EMPLOYER QUESTIONNAIRE

QUESTIONNAIRE TO SELECTED EMPLOYER REPRESENTATIVES

How many of your employees spend all or part of their work week engaged in each of the following activities:

		Number of Workers	% Total Labour Force	Estimated Average Length of Service
WELDING:	Full-time			
	Part-time			
BRAZING:	Full-time			
	Part-time			
FLAME CUTTING:	Full-time			
	Part-time			
METAL SPRAYING:	Full-time			
	Part-time			

In order to derive an estimate of man-hours spent per task in each four risk environments, could you contribute information along the following lines:

ESTIMATE OF MAN-HOURS PER MONTH IN FOUR ENVIRONMENTS				
ENVIRONMENT	INDOORS		OUTDOORS	
TASK	In Designated Area i.e. Manufacturing	In Changing Locations i.e. Maintenance	In Designated Area i.e. Manufacturing	In Changing Locations i.e. Maintenance
Welding				
Brazing				
Flame Cutting				
Metal Spraying				

Compensation Claims: Could you indicate how may fume exposure claims have been formally processed and the outcome of the claims?

CLAIMS / TASK	Resolved with no Chronic Respiratory Impairment	*Resolved with Evidence of Chronic Respiratory Impairment
2.1 Welding		
2.2 Brazing		
2.3 Flame Cutting		
2.4 Metal Spraying		

* Only an impaired condition medically attributed to occupational fume exposure need be recorded.

How many employees not classified in 2.1, 2.2, 2.3, and 2.4 above are likely to be exposed to fume generated at these activities:

3.1 Estimated number =

3.2 % of work force =

Are there situations in your plant where hydrocarbon solvent vapours are likely to be exposed to ultraviolet radiations generated by welders?

Medical Surveillance

Could you indicate YES or NO if the following surveillance is made on a planned basis:

	SURVEILLANCE TASK	Lung Function Tests	Biological Monitoring	Routine Medical Examinations	Pre-employment Medical Examination	Air Sampling	Employee Exposure Records
SPECIFICALLY	6.1 Welders						
	6.2 Brazers						
	6.3 Flame Cutters						
	6.4 Metal Sprayers						
	6.5 All Trades						

Employee Attitudes

Would you say that there is any indication of an increasing awareness by individual employees or their labour representatives of the health implications of welding fumes.

Could you advise if your company organizes a health and safety training program for workers engaged in:

	YES	NO
Welding		
Brazing		
Flame Cutters		
Metal Sprayers		

ORGANIZATION UNDER TREASURY BOARD AND LABOUR CANADA

List of Organizations Under the Labour Jurisdiction of the Treasury Board and Thus Excluded from Coverage by the Canada Labour Code Pt IV - From Schedule I, Public Service Staff Relations Act

Part I

Departments and other portions of the Public Service of Canada in respect of which Her Majesty as represented by the Treasury Board, is the employer

Departments named in Schedule A to the Financial Administration Act
Agricultural Stabilization Board
Atlantic Development Board
Board of Grain Commissioners
Canadian Dairy Commission
Canadian Government Elevators
Canadian Livestock Feed Board
Canadian Penitentiary Service
Canadian Pension Commission
Canadian Radio-Television Commission
Canadian Transport Commission
Director of Soldier Settlement
The Director, The Veterans' Land Act
Dominion Bureau of Statistics
Dominion Coal Board
Emergency Measures Organization
Canadian International Development Agency
Fisheries Prices Support Board
Government Printing Bureau
Immigration Appeal Board
International Joint Commission (Canadian Section)
Maritimes Marshland Rehabilitation Administration
Municipal Development and Loan Board
National Capital Commission
National Energy Board
National Library
National Museums of Canada
National Parole Board
Office of the Auditor General of Canada
Office of the Chief Electoral Officer
Office of the Comptroller of the Treasury
Office of the Governor-General's Secretary
Office of the Representation Commissioner
Office of the Superintendent of Bankruptcy
Prairie Farm Assistance Administration
Prairie Farm Rehabilitation Administration
Privy Council Office
Public Archives
Public Service Commission
Restrictive Trade Practices Commission
Royal Canadian Mounted Police
Staff of the Exchequer Court
Staff of the Supreme Court
Statute Revision Commission
Tariff Board
Tax Appeal Board
Unemployment Insurance Commission
War Veterans Allowance Board

Part II

Portions of the Public Services of Canada that are separate employers

Atomic Energy Control Board
Centennial Commission
Defence Research Council
Economic Council of Canada
Medical Research Council of Canada
Northern Canada Power Commission
Public Service Staff Relations Board
Science Council Canada
Fisheries Research Board

List of Crown Corporations
Administered Under Canada Labour Code
Part IV

Departmental Corporations
- Agricultural Stabilization Board
- Atomic Energy Control Board
- Economic Council of Canada
- Fisheries Prices Support Board
- Medical Research Council
- National Museums of Canada
- National Research Council of Canada
- Science Council of Canada
- Unemployment Insurance Commission

Agency Corporations
- Atomic Energy of Canada Limited
- Canadian Arsenals Limited
- Canadian Commercial Corporation
- Canadian Dairy Commission
- Canadian Film Development Corporation
- Canadian Livestock Feed Board
- Canadian Patents and Development Limited
- Canadian Saltfish Corporation
- Crown Assets Disposal Corporation
- Defence Construction (1951) Limited
- National Battlefields Commission
- National Capital Commission
- National Harbours Board
- Northern Canada Power Commission
- Petro-Canada
- Royal Canadian Mint
- Uranium Canada Limited

Proprietary Corporations
- Air Canada
- Atlantic Pilotage Authority
- Canada Deposit Insurance Corporation
- Canada Mortgage and Housing Corporation
- Canadian Broadcasting Corporation
- Teleglobe Canada
- Cape Breton Development Corporation
- Eldorado Aviation Limited
- Eldorado Nuclear Limited
- Export Development Corporation
- Farm Credit Corporation
- Freshwater Fish Marketing Corporation
- Great Lakes Pilotage Authority
- Laurentian Pilotage Authority
- Loto Canada Inc.
- National Railways
- Northern Transportation Company Limited
- Pacific Pilotage Authority
- St. Lawrence Seaway Authority
- Seaway International Bridge Corporation Limited

Unclassified Corporations
- Bank of Canada
- Canada Council
- Canadian Wheat Board
- Federal Business Development Bank
- National Arts Centre Corporation

DEPARTMENT OF LABOUR REGIONAL OFFICES

Headquarters Office

Location: Place du Portage, Phase II
Hull, Quebec

Mailing Address: Labour Canada
Ottawa, Ontario
K1A 0J2

Regional Offices

1. Atlantic Region
P.O. Box 2967
Station "A"
Moncton, New Brunswick
E1C 8T8

2. St. Lawrence Region
Port of Montreal Building
2nd Floor, 3rd Wing
Cité du Hâvre
Montreal, Quebec

3. Great Lakes Region
Mezzanine, Suite 200
4900 Yonge Street
Willowdale, Ontario
M2N 6C3

4. Central Region
Canadian Grain Commission Building
400-303 Main Street
Winnipeg, Manitoba
R3C 3G7

5. Mountain Region
7th Floor, 750 Cambie St.
Vancouver, British Columbia
V6B 2P2

LEGEND

✓ - PSC have Appointment Power re Staff
● - PSC have no Appointment Power re Staff
X - Appointment Jurisdiction Divided

FEDERAL PUBLIC SERVICE

THE PERSONNEL MANAGEMENT INTER-RELATIONSHIPS OF THE FINANCIAL ADMINISTRATION ACT - THE PUBLIC SERVICE STAFF RELATIONS ACT - THE PUBLIC SERVICE EMPLOYMENT ACT

PREPARED BY: General Personnel Management Division
Treasury Board Secretariat
Revised May, 1979

FAA Classification	Subject to Public Service Staff Relations Act (Schedule 1 Part 1)	Subject to Public Service Staff Relations Act (Schedule 1 Part 2)	Subject to Canada Labor Code Part V	Subject to Other Authorities for Terms and Conditions of Employment
SCHEDULE A - DEPARTMENTS	✓ Department of Agriculture			
	✓ Department of Communications			
	✓ Department of Consumer & Corporate Affairs			
	✓ Department of Employment & Immigration (Note 1)			
	✓ Department of Energy, Mines & Resources			
	✓ Department of Environment			
	✓ Department of External Affairs			
	✓ Department of Finance			
	✓ Department of Fisheries & Oceans (Note 2)			
	✓ Department of Indian & Northern Affairs			
	✓ Department of Industry, Trade & Commerce (includes Foreign Investment Review Agency			
	✓ Department of Insurance			
	✓ Department of Justice			
	✓ Department of Labour			
	✓ Department of National Defence Defence Research Board			
	✓ Department of Health & Welfare			
	✓ Department of National Revenue			
	X Post Office Department			
	✓ Department of Public Works			
	✓ Department of Regional Economic Expansion			
	✓ Department of the Secretary of State			
	✓ Department of the Solicitor General			
	✓ Department of Supply & Services			
	✓ Department of Transport			
	✓ Treasury Board			
	✓ Department of Veterans Affairs			

Notes:

1. Established by SC 1976-77 C.54
2. Established by SC 1978-79 C.13

LEGEND

√ - PSC have Appointment Power re Staff
● - PSC have no Appointment Power re Staff
X - Appointment Jurisdiction Divided

Revised May 1979

FAA Classification	Subject to Public Service Staff Relations Act (Schedule 1 Part i)	Subject to Public Service Staff Relations Act (Schedule 1 Part 2)	Subject to Canada Labor Code Part V	Subject to Other Authorities for Terms and Conditions of Employment
SCHEDULE B DEPARTMENTAL CORPORATIONS	● Agricultural Stabilization Board √ Director of Soldier Settlement (DVA) √ The Director, The Veterans Land Act (DVA) ● Fisheries Prices Support Board (DFO) ● Municipal Development and Loan Board √ National Museums of Canada	● Atomic Energy Control Board ● Economic Council of Canada ● Medical Research Council ● National Research Council ● Science Council of Canada ● Natural Sciences and Engineering Research Council (Note 1) ● Social Sciences and Humanities Research Council (Note 2)		
SCHEDULE C - AGENCY CORPORATIONS	● Canadian Dairy Commission ● Canadian Livestock Feed Board ● National Capital Commission	● Northern Canada Power Commission	● Atomic Energy of Canada Ltd ● Canadian Arsenals Ltd ● Canadian Commercial Corporation ● Canadian Film Development Corporation ● Canadian National (West Indies) Steamships Ltd ● Canadian Patents and Development Ltd ● Canadian Saltfish Corporation ● Crown Assets Disposal Corporation ● Defence Construction (1951) Ltd ● Loto Canada Inc ● National Battlefields Commission ● National Harbours Board ● Royal Canadian Mint ● Uranium Canada Ltd	

Notes:

1. Established by PC 1978-1336 dated 20.4.78
2. Established by PC 1978-909 dated 23.3.78

LEGEND

√ - PSC have Appointment Power re Staff
● - PSC have no Appointment Power re Staff
X - Appointment Jurisdiction Divided

Revised May 1979

FAA Classification	Subject to Public Service Staff Relations Act (Schedule 1 Part 1)	Subject to Public Service Staff Relations Act (Schedule 1 Part 2)	Subject to Canada Labor Code Part V	Subject to Other Authorities for Terms and Conditions of Employment
SCHEDULE D - PROPRIETARY CORPORATIONS			● Air Canada ● Canada Deposit Insurance Co. Ltd. ● Canada Mortgage & Housing Corp. ● Canadian Broadcasting Corporation ● Cape Breton Development Corp. ● Eldorado Aviation Ltd. ● Eldorado Nuclear Ltd. ● Export Development Corporation ● Farm Credit Corporation ● Federal Business Development Bank ● Federal Mortgage Exchange Corporation ● Freshwater Fish Marketing Corp. ● National Railways (as defined in CN-CP Act) ● Northern Transportation Co. Ltd. ● Petro-Canada ● Pilotage Authorities: - Atlantic - Great Lakes - Laurentian - Pacific ● Polysar Limited ● St. Lawrence Seaway Authority ● Seaway International Bridge Corporation Ltd ● Teleglobe Canada ● Via Rail Canada Incorporated (Note 1)	

Notes:

1. Established by PC 1978-954 dated 23.3.78

LEGEND
√ - PSC have Appointment Power re Staff
● - PSC have no Appointment Power re Staff
X - Appointment Jurisdiction Divided

Revised May 197

FAA Classification	Subject to Public Service Staff Relations Act (Schedule 1 Part 1)	Subject to Public Service Staff Relations Act (Schedule 1 Part 2)	Subject to Canada Labor Code Part V	Subject to Other Authorities for Terms and Conditions of Employment
BRANCHES AND DIVISIONS DESIGNATED AS DEPARTMENTS	√ Ministry of State for Science and Technology √ Ministry of State for Economic Development (Note 1) √ Anti-Inflation Board √ Anti-Inflation Act Office of the Coordinator √ Appeal Tribunal (Note 2) √ Canadian Human Rights Commission √ Canadian International Development Agency √ Canada Labour Relations Board √ Canadian Intergovernmental Conference Secretariat √ Canadian Penitentiary Service √ Canadian Radio-Television & Telecommunications Commission √ Canadian Transport Commission √ Chief Electoral Officer √ Commissioner of Official Languages X Federal-Provincial Relations Office √ Governor-General s Secretary √ Immigration Appeal Board √ National Commission on Inflation (Note 3) √ National Energy Board √ National Library √ National Parole Board √ Office of the Commissioner for Federal Judicial Affairs (Note 4) √ Office of the Co-ordinator on the Status of Women √ Petroleum Compensation Board (Note 5) √ Privy Council Office √ Public Archives √ Public Service Commission √ Restrictive Trade Practices Commission √ Royal Canadian Mounted Police √ Statistics Canada √ Supreme Court of Canada (Note 6)	● Auditor General ● National Film Board √ Public Service Staff Relations Board ● Northern Pipeline Agency (Note 7)		● Criminal Code Revision Commission ● House of Commons Staff ● Library of Parliament ● Senate Staff ● Commissions of Inquiry - Activities of RCMP - Indian Claims Commission - Farm Machinery - Marketing of Beef - Royal Commission on Corporate Concentration - Commission on Prairie Grain Handling and Transportation - Financial Management and Accountability ● Special Inquirer for Elder Indians Testimony

Notes:

1. Established by P-oclamation d. 19.12.78
2. Established by SC 1975, C75
3. Established by PC 1979-880 d. 22.3.79
4. Established by PC 1978-257 d. 26.1.78
5. Established by SC 1977-78, C24
6. Established by PC 1978-256 d. 26.1.78
7. Established by PC 1978-369 d. 19.2.78

LEGEND
√ - PSC have Appointment Power re Staff
● - PSC have no Appointment Power re Staff
X - Appointment Jurisdiction Divided

Revised May 1979

FAA Classification	Subject to Public Service Staff Relations Act (Schedule 1 Part 1)	Subject to Public Service Staff Relations Act (Schedule 1 Part 2)	Subject to Canada Labor Code Part V	Subject to Other Authorities for Terms and Conditions of Employment
BRANCHES AND DIVISIONS DESIGNATED AS DEPARTMENTS	● Statute Revision Commission √ Tariff Board X Task Force on Canadian Unity			
ORGANIZATIONS NOT LISTED IN FAA SCHEDULES	● Atlantic Development Council √ Canadian Grain Commission √ Bureau of Pension Advocates √ Canadian Pension Commission √ Federal Court √ Fisheries Research Board (DFO) √ International Joint Commission (Canadian Section) √ Law Reform Commission ● Maritime Marshland Rehabilitation Administration √ Pension Review Board √ Prairie Farm Rehabilitation Administration √ Staff of the Supreme Court √ Superintendent of Bankruptcy (DCCA) √ Tax Review Board √ War Veterans Allowance Board	● Canadian Centre for Occupational Health and Safety (Note 1) ● Communications Security Establishment (Note 2)	● Bank of Canada ● Blue Water Bridge Authority ● Canada Council ● Canadian Corp. for 1967 World Exhibition ● Canadian Wheat Board ● Harbour Commission(s) - Belleville - Hamilton - Lakehead - Oshawa - Toronto - Windsor - Fraser, New Westminster - Nanaimo - Fort Alberni ● International Development Research Centre ● National Arts Centre Corporation ● Standards Council of Canada	● Advisory Council on the Status of Women ● Correctional Investigator ● Office of the Custodian of Enemy Property ● Government of Northwest Territorie ● Government of the Yukon Territory ● Metric Commission ● Commissions of Inquiry - Airport Inquiry Commission - Commission to Investigate citizen complaints against RCMP Members, and the Internal Discipline and Grievance Procedures of the RCMP - Commission into Air Canada - Commission re Construction of a Marine Terminal at Kitimat, B.C. - Canadian Unity - Operations and policies of the RCMP Security Service on a National Basis

Notes:

1. Established by SC 1977-78 Chap. 29 Section 3
2. Established by PC 1975-708, 27 Mar 76
PC 1975-709, 27 Mar 76
PC 1975-686, 25 Mar 75

APPENDIX V

LABOUR AND TRADE GROUPINGS

Welding

Aircraft Welder - Machinist - by welding component parts frequent exposure to welding fumes	Aircraft Maintaining
Aircraft Mechanic - repairs fuselage, wings, controls surfaces using oxyacetylene welder occasional exposure to fumes	Aircraft Maintaining
Welder, Combination - welding brazing using oxyacetylene equipment frequent exposure to welding fumes	Manipulating
Body Repairman - by welding tears using oxyacetylene equipment	Sheet Metal Working
Pipefitter, Welding - by welding component parts continual exposure to heat, fumes and dirt when using welding and forging equipment	Pipefitting
Mechanic, Airport - by welding, brazing and cutting metal parts using oxyacetylene and electric-arc equipment - occasional exposure to welding fumes	Vehicle and Heavy Equipment Maintaining
Millwright, Airport - by drilling, grinding and welding using electric-arc and oxyacetylene equipment - occasional exposure to welding fumes	Machinery Maintaining

Contact with Welding Fumes

Metal Fabricator, Marine Aids - directs welders	Boilermaking-Blacksmithing
Shop Superintendent, Marine Aids - reviews, inspects and assesses work of welders	Boilermaking-Blacksmithing
Sheet-metal working - often in same workshop as welder	Sheet-metal Worker
Helper-Trades - could be helper to welder	Elemental

QUESTIONNAIRE FOR PROVINCIAL JURISDICTION

HEALTH AND WELFARE CANADA

STUDY OF EXPOSURE TO WELDING FUME

LEGISLATION AND ENFORCEMENT

Could you name all the Provincial Act(s) existing or proposed which contain legislation covering the occupational health of persons employed in welding and the associated operations of flame cutting, brazing and metal spraying?

Are there any regulations contained in the above legislation which address specifically the health hazards experienced by welders, flame cutters, brazers and metal sprayers?

Are there any groups of welders etc. operating within the province who are specifically excluded from provincial occupational health legislation?

What Ministry, Department or Branch is responsible for enforcing the occupational health regulations concerning persons employed in welding and associated operations? i.e.:

Who inspects welding operations?

Who advises inspectors on occupational health issues?

Who issues directions to employers in violation?

Who follows up to ensure that the directions are complied with?

ADMINISTRATIVE

How many government field staff are available for inspection and monitoring of general occupational health environments at:

Industrial plant

Construction sites

Mining operations

Other places of employment covered by provincial occupational health legislation not included above?

Does the government provide occupational health hazard control advice as part of its occupational health service?

Is there a provincially sponsored occupational health education program catering to workers employed in welding and associated operations?

RECORDS

Are occupational environment exposure records of welders maintained by:

The Provincial Occupational Health Service or Safety Branch?

The Workmen's Compensation Board?

Employers, under statute of law?

Labour organizations?

The provincial government, for its own employees?

Can you comment on the availability of employment medical records of welders and associated workers employed in the private and public sectors?

Where records are maintained as mentioned in above paragraphs, is there a legal requirement to divulge these to the workers concerned?

Could you estimate the number of workers in the province employed full or part-time in the four areas of:

Welding

Flame cutting

Brazing

Metal spraying

TECHNICAL

What criteria, including specific Threshold Limit Values, are applied in the evaluation of worker exposure to fumes from welding and associated operations?

Could you list a sample of principal firms and other organizations (such as Crown corporation establishments) in the province employing welders, flame cutters, brazers and metal sprayers, in the following groups:

Private firms

Crown corporations

Federal establishments other than Crown corporations

Provincial or municipal establishments?

LIST OF CO-RESPONDENTS

The following is a list of persons who responded to our personal and telephone communications on the subject of welding health hazard. It is not intended to be a complete record of all those who were kind enough to provide insight and advice on the subject.

Dr. Frank Mitchell, NIOSH, Rockville, Md.
Ms. Sonia Berg, Criteria Document Manager, NIOSH, Rockville, Md.
Dr. E. Mastromatteo, International Nickel Co.
Dr. Peter Palmier, Govt. of Ontario, Occupational Health and Safety Division
Dr. D.F. Burton, Ontario WCB
Dr. R.W. Tooley, New Brunswick, Occupational Health and Safety Division
Mr. G.P. Wood, Newfoundland, Department of Labour
Dr. V. Rabinovitch, Canadian Labour Congress
Dr. J. Cowell, Canadian General Electric
Mr. D. Fulton, Industrial Hygienist, Ontario Hydro
Dr. Roland Hosein, University of Newcastle-Upon-Tyne Medical School
Dr. John Steel, Toronto, Faculty of Medicine (Community Health)
T.G. Ison, Queen's University at Kingston, Industrial Relations Centre; Professor, Faculty of Law
Mr. George Scattergood, Government of Saskatchewan, Senior Industrial Hygienist
Ms. Susan Arnold R.N., Port Weller Dry Dock Co. Ltd., St. Catharines, Ontario
Karl F. Doerwald, GM Canada Ltd., Industrial Hygienist
J. Norman Lockington, DOFASCO Inc., Hamilton, Ont., Manager of Occupational Environment
Mr. R. Ryckman, Algoma Steel Corporation

APPENDIX VIII

ONTARIO WORKMEN'S COMPENSATION BOARD STATISTICS

The Ontario Workmen's Compensation Board

Claims Allowed (1971 and 1973-1978)*

Total Claims Allowed	1971 350 000 (approx.)	1973 418 438 (approx.)	1974 443 000 (approx.)	1975 395 528 (approx.)	1976 433 799 (approx.)	1977 395 146 (approx.)	1978 385 945 (approx.)
Total Industrial Diseases	2 651	2 766	5 002	4 990	6 310	8 120	6 834
Occupational Dermatitis	1 300	1 417	1 515	1 242	1 245	1 105	839
Fume Toxicity	830	1 055	1 111	1 062	1 478	1 352	1 439
Occupational Noise Deafness	248	258	986	639	1 454	2 084	1 379
Tendinitis, Tensynovitis, Bursitis, Carpal Tunnel Syndrome, etc.	---	---	975	566	700 (est.)	767	498
UVL Flash Burns	---	---	---	958	900 (est.)	963	996
Infectious Diseases	203	120	234	187	160	137	113
Heart Claims (not included in total industrial diseases for 1977, 1978)	44	50	32	36	39	38	50
Effects of Reduced Temperature	---	---	---	38	112	---	61
White Hand Syndrome	---	---	---	---	68	45	110
Silicosis	36	50	48	73	60	46	24
Asbestosis	3	10	3	41	29	38	12
Silico-Asbestosis	2	---	4	---	---	---	---
Lead**	11	26	57	30	16	23	29**
Effects of Heat	---	---	---	27	14	---	13
Malignancies	5	---	---	16	38	50	41
Pneumoconiosis	---	---	---	---	---	---	3

* Compiled by H.M. Nelson from Workmen's Compensation Board Records.
** Included in fume toxicity.

Industrial Diseases (Cont'd.)	1971	1973	1974	1975	1976	1977	1978
Ionizing Radiation	13	---	---	22	1	---	50*
Asthmatic Bronchitis	---	15	37	14	22	26	12
Fatal Claims (not included in total industrial diseases)	---	---	---	---	---	226	261
Chemical Burns to Skin and Eyes	---	---	---	---	---	1 175	1 191
Miscellaneous	---	---	---	---	---	45	177
Total Fume Intoxication	830	1 055	1 111	1 062	1 478	1 352	1 439
Carbon Monoxide	121	100	176	140	254	206	197
Chlorine	176	281	119	137	215	221	244
Smoke	110	156	141	163	211	277	300
Solvents	76	109	135	78	67	91	63
Plastics	36	---	---	54	33	---	75
Welding Fumes (Metal Fume Fever)	36	131	41	47	48	---	40
Ammonia	34	32	40	65	55	---	64
Blasting Fumes	18	19	---	10	3	---	9
Toluene di-isocyanate	18	11	---	13	28	---	9
Pesticides	10	31	32	19	38	---	40
Cadmium	8	---	---	10	1	---	1
Sulphur Dioxide	---	12	39	39	36	---	19
Oxides of Nitrogen	---	11	---	24	7	---	12
Hydrogen Sulphide	---	---	27	12	16	---	11

* Without apparent injury.

Fume Intoxication (Cont'd.)	1971	1973	1974	1975	1976	1977	1978
Paint Fumes	---	---	23	27	57	---	69
Acid Fumes	---	---	---	47	90	---	84
Lead	---	---	---	30	16	---	29
Carbon Dioxide	---	---	---	15	2	---	17
Sewer Fumes	---	---	---	13	6	---	7
Caustic Fumes	---	---	---	6	19	---	13
Phosgene	---	---	---	6	6	---	5
Cyanide Fumes	---	---	---	5	19	---	3
Formaldehyde	---	---	---	5	3	---	6
Nickel Carbonyl	---	---	---	5	1	---	1
Tar and Creosote	---	---	---	3	---	---	2
Fibreglass Particles	---	---	---	3	1	---	---
Freon	---	---	---	1	16	---	7
Mercury	---	---	---	---	1	---	6
Miscellaneous	187	151*	338*	85*	239*	---	106

*Numbers do not agree with Workmen's Compensation Board Reports.

MATERIAL SAFETY EVALUATION
Industrial Hygiene Department

HAZARDOUS MATERIAL
CONTACT FOREMAN FOR HANDLING INSTRUCTIONS

ASC Emp. Rel. - 204 Rev. 10/78

PRODUCT IDENTIFICATION

Effective Feb. 18/8

Product Name	Staymet 40 Hardsurfacing Electrode		
Product Type	Welding Rod		
Manufacturer	Staymet Alloys Ltd.	Emergency Telephone Number	
Address	Box 85, Pitt Meadows, B.C. V0M 1P0		
Distributor	Master Welding	Telephone Number	705-674-7777
Address			

HAZARD RATING

	Low	Moderate	High	Extreme
Health Hazard Rating	■	■	■	
Fire Hazard Rating	Nonflammable			

EFFECTS OF OVEREXPOSURE

Inhalation of Welding Fume - May cause dry sensation or irritation to nose and throat

Skin - Fume may cause skin irritation

CAUTION - Material contains a suspected cancer causing agent

OVEREXPOSURE FIRST AID

→ In all cases of suspected overexposure contact Medical immediately: Tel. - 2241

Inhalation of Welding Fume - Remove to fresh air

Skin - Wash thoroughly with soap and water

HANDLING PRECAUTIONS

Storage Keep dry

Ventilation Local mechanical exhaust

Protective Equipment 3M-9910 respirator (037 5305) when local exhaust is unavailable. Regular welding equipment

Fire Extinguishing Media Not applicable

Special Precautions Long term, high concentration exposures require a powered air purifying respirator.

Waste Disposal Normal waste containers

PLANT USERS OF PRODUCT

Stores Code 030-9317

Evaluated By: ______________ Date: Revised February 28, 1980

MATERIAL SAFETY EVALUATION
Industrial Hygiene Department

ASC Emp. Rel. - 204 Rev. 10/78

HAZARDOUS MATERIAL
CONTACT FOREMAN FOR HANDLING INSTRUCTIONS

PRODUCT IDENTIFICATION

Effect. Feb. 18/80

Product Name Oxweld 25M Bronze Rod
Product Type Welding Rod
Manufacturer Union Carbide Canada Ltd. Emergency Telephone Number
Address 123 Eglinton Ave. E. Toronto, Ontario M4P 1J3
Distributor Morgan Welding Phone No. 949-5444
Address 497 Second Line E. Sault Ste.

HAZARD RATING

	Low	Moderate	High	Extreme
Health Hazard Rating	■	■	■	
Fire Hazard Rating	Nonflammable			

EFFECTS OF OVEREXPOSURE

Inhalation of fume - May cause high fever, chills, shaking, metallic taste in mouth (Metal fume fever). Symptoms begin 6-8 hours after exposure and pass 24 hours after exposure.

OVEREXPOSURE FIRST AID

→ In all cases of suspected overexposure contact Medical immediately: Tel. - 2241

Inhalation of fume - Remove to fresh air. Give large volumes of liquid. If symptoms of metal fume fever develop, get medical attention.

HANDLING PRECAUTIONS

Storage Keep dry
Ventilation Local mechanical exhaust
Protective Equipment 3M-9910 respirator for welding (Stores Code 037 5305), normal welding equipment
Fire Extinguishing Media Not applicable.
Special Precautions Long term, high concentration exposures require a powered air purifying respirator
Waste Disposal Normal waste containers

PLANT USERS OF PRODUCT

Stores Code 1/8" 030 9333 3/16" 030 9334 1/4" 030 9335

Evaluated By:

Date: Revised Feb. 6, 1980

MATERIAL SAFETY EVALUATION
Industrial Hygiene Department

ASC Emp. Rel. - 204 Rev. 10/78

551-2207

PRODUCT IDENTIFICATION

Product Name Allstate Chamfer Rod 5/32"
Product Type Welding Rod
Manufacturer Chemetron of Canada Ltd. Emergency Telephone Number 416-266-1123
Address 110 Jutland Road, Toronto, Ont. M8Z 2H1
Distributor Morgan Welding Supply Emergency Telephone Number 949-5444
Address 497 2nd Line E., Sault Ste. Marie, Ont.

HAZARD RATING

	Low	Moderate	High	Extreme
Health Hazard Rating	▬			
Fire Hazard Rating	Nonflammable			

EFFECTS OF OVEREXPOSURE

Inhalation of fume - May cause nose and throat irritation (dry sensation)
May produce non-disabling spotting of lung on X-ray plate (Siderosis)

OVEREXPOSURE FIRST AID

→ In all cases of suspected overexposure contact Medical immediately: Tel. - 2241

Inhalation of fume - Remove to fresh air.

HANDLING PRECAUTIONS

Storage Keep dry
Ventilation General exhaust
Protective Equipment 3M Model 9910 Respirator. Normal welding equipment.
Fire Extinguishing Media Not applicable
Special Precautions Discard damaged or wet electrodes.
Waste Disposal Normal waste containers

PLANT USERS OF PRODUCT

Stores Code 562-2462

Evaluated By: ______________ Date: January 31, 1979

MATERIAL SAFETY EVALUATION
Industrial Hygiene Department

ASC Emp. Rel. - 204 Rev. 10/78

551-2207

PRODUCT IDENTIFICATION

Product Name 9018-B3L Easyarc 341
Product Type Welding Rod
Manufacturer Arcweld Products Ltd. Emergency Telephone Number 514-744-4961
Address 905 Hodge Street, St. Laurent, Quebec.
Distributor
Address

HAZARD RATING

	Low	Moderate	High	Extreme
Health Hazard Rating	▬	▬		
Fire Hazard Rating	Nonflammable			

EFFECTS OF OVEREXPOSURE

Inhalation of Fume - May cause nose and throat irritation (dry sensation).
May produce non-disabling spotting of lung on x-ray plate (Siderosis).

OVEREXPOSURE FIRST AID

→ In all cases of suspected overexposure contact Medical immediately: Tel. - 2241

Inhalation of Fume - Remove to fresh air.

HANDLING PRECAUTIONS

Storage Keep dry.
Ventilation General exhaust
Protective Equipment 3M Model 9910 Respirator. Normal welding equipment.

Fire Extinguishing Media Not applicable.
Special Precautions Discard damaged or wet electrodes.

Waste Disposal Normal waste containers.

PLANT USERS OF PRODUCT

Stores Code - 3/16" 049-0074

Evaluated By: Date: February 19, 1979